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The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Aluminium

In the daily reports furnished by the newspapers of trading in base metals, one looks in vain, generally speaking, for any reference to aluminium. The explanation is not far to seek, for this commodity has no future market in the same way as copper and tin. Price stability, admirable as it is, does not lead to a keen interest by the general public, who cannot see any chance of a speculative dabble. Nevertheless, aluminium is very much in the limelight just now, for in connection with the great expansion in our air force there is a big demand for the light alloys bulking so largely in the manufacture of aircraft. It would, of course, be wrong to conclude that it is this need alone which is keeping aluminium producers so busy, for, actually, extension of armament forms only a part of the outlet for aluminium at the present time, and in many directions entirely peaceful pursuits are taking annually a big tonnage of this metal. Moreover, attention is all the time being given to the possibility of finding fresh outlets, and we may be quite sure that when the rearmament demand dies down other channels of use will be available.

It will be remembered that only a few weeks ago a reduction of £4 was made in the price of aluminium, and since this was done at a time when demand is expanding, it is pretty evident that the producers are not "on the make." The nickel interests did something similar in January last year, when they reduced the price from £200 to £180, and the wisdom of their action became apparent when, in the early months of 1937, the base metals reacted so sharply. Price is always a matter for careful consideration by the producers or manufacturers of any commodity, and there can be no doubt that the aluminium consortium will give this matter very careful consideration. Compared with zinc or lead, aluminium has always been a fairly high-priced metal, but one has to remember its relatively low density; it is, for example, approximately one-third the weight of copper, bulk for bulk. The price reduction in aluminium referred to above was certainly not made necessary by any falling off in demand making it needful to tempt consumers to buy, since consumption is maintained at a very good rate. Rival metals, too, such as copper, which at present stands at about half the price of aluminium, do not cause any anxiety; if anything, the boot is rather on the other foot.

As to the statistical side of the picture, the present year has resulted in something of an accumulation of scrap of various kinds, mainly as a result of the withdrawal of Japan as a buyer on this market. Recently, however, this demand has been renewed, and scrap will probably not be so plentiful as it has been during the past months. Not unnaturally the United States comes first among the consuming countries of the world, her total usage last year being in the neighbourhood of 145,000 tons, while Germany comes second and not very far behind. This country makes rather a bad third, but our rate of use just now must be around 50,000 tons per annum and it will probably increase. Unfortunately, our production falls a good deal short of consumption and we have to import a large quantity, the bulk of it from Canada, but also from Switzerland and Norway. Production of aluminium is widely distributed and the world's total is now approaching the half million mark, as fresh openings are found for the use of this metal. It is not suggested that the consumption of aluminium can be expanded indefinitely, but undoubtedly a very wide scope exists for its use, and this is well illustrated by developments in the transport industry, especially in America. Lightness combined with strength is the ideal in such a case, and these qualities are provided by alloys of aluminium.

All things considered, it must be admitted that the outlook for aluminium is distinctly favourable, and the fact that the price is stable and not subject to the wide fluctuations seen in other directions is a factor which cannot fail to encourage the use of this metal all over the world.

French Foundry Industry

(FROM OUR PARIS CORRESPONDENT.)

In spite of the general dissatisfaction and even the uncertainty of execution of the series of decree laws promulgated by the French Government, business as regards both pig-iron and castings has shown an upward tendency. The reason for this move is the certainty that the new taxes will bring with them an increase in prices, against which many consumers wish to guarantee themselves.

Another factor is the feeling that, even if changes are made in the present laws, some serious effort will have to be made by the Government to increase production. This would mean improved business and rising prices in any case. The feeling, therefore, is optimistic in spite of a measure of uncertainty.

More Blast Furnaces

Production of pig-iron during the past month or two has been definitely up over the early part of the year. Total production for the first ten months was 378,000 tons, but the figures for September (65,000 tons) and October (56,000 tons) indicate a definite move towards greater production. Another indication is the re-lighting of three blast furnaces, bringing the total of furnaces in service to 78. The possibility of further furnaces being relighted is seriously considered.

Founders, on the other hand, report little change in their situation. Activity is extremely unequal, certain plants working to capacity while others have difficulty in maintaining a minimum of activity. Fair business continues to be done in castings for heating plant, especially radiators and stoves, for which demand continues moderate. Castings for agricultural machines show less activity, and founders are having a little difficulty in keeping open.

Price Difficultie

Certain founders, notably those producing cast-iron brake shoes for the railways, complain violently about the difficulties in obtaining a reasonable price. In 1930, they explain, pig-iron was worth 490 fcs. per ton, and brake shoes sold at 125 fcs. per metric cwt. Both the pig and the shoes paid a production tax of 2 per cent. Now, with pig at 598 fcs., the shoes, without tax, cost 124.25 fcs. The tax on pig is now repealed, but that on shoes is 8.7 per cent. Railways complain that shoes have gone up, and refuse to pay the higher prices, whereas shoes have actually gone down. The increase in the price is due to extra taxes.

It is considered certain, however, that founders will begin a general, though slow, increase in their prices from early December, so as to cover the expected rise in costs.

New Iron-Ore Deposit in Transvaal

A new deposit of iron ore near Wolmaransstad, Transvaal, outcrops over a distance of ten miles and goes to an unknown depth, at present estimated at 1,000 ft.; it is known to go down at least 50 ft., on which basis there is estimated to be an ore body of 15,000,000 tons of hematite. If these calculations are correct, it is claimed that the deposit is one of the world's largest, outside of the United States and Sweden. The ore is said to average 63.5 per cent. iron content and is claimed to be remarkable for its low content of sulphur (0.603 per cent.) and of silica (0.3 per cent.) and for the virtual absence of phosphorus. It is proposed to export a considerable amount of the iron ore through Durban, and trial orders have been obtained from Germany and Czecho-Slovakia. In addition, it is proposed to put up a small blast furnace at Maritzburg for the manufacture of charcoal pig-iron, and also to study the suitability of the Krupp "Rennverfahren."

Notes from the Branches

WEST RIDING OF YORKSHIRE BRANCH

Members of the West Riding of Yorkshire Branch of the Institute of British Foundrymen, on November 12, made an unusual departure from usual practice by visiting the works of a well-known firm of engineers who specialise notably in machinery for newspapers and the printing industry. The visit was to the works of R. W. Crabtree & Sons, Limited, Water Lane, Leeds. The interest in the occasion was evident by an attendance of about 100, which ranks among the largest attendances on a works visit in the history of the Branch. The party, led by Mr. A. S. Worcester (Branch-President) and Mr. S. W. Wise, the hon. secretary, were welcomed at the company's offices by Mr. Peter N. Crabtree, one of the directors; Mr. T. Blake, the general works manager, and Mr. J. H. Wright, the foundry manager. Under their guidance, and members of the staff, the visitors in small parties spent an afternoon of intense interest in a tour of the works, including the firm's own foundry, and seeing many phases of engineering practice which are not to be found in the generality of engineering shops.

After tea, as guests of the firm, Mr. Peter Crabtree gave a lecture, illustrated by lantern slides, on machines used in the production of great newspapers. In the course of his remarks, Mr. Crabtree gave the composition of the type metal as 82 per cent. lead, 13 per cent. antimony and 5 per cent. tin, and that of the actual printing plates as 74 per cent. lead, 16 per cent. antimony and 10 per cent. tin. The melting points of the two alloys are 232 and 260 deg. C. The increased tin content gives a tougher and better wearing surface to the type. The lecturer gave a complete account of the mechanical production of a daily newspaper.

EAST ANGLIAN SECTION

At a meeting held on November 18, over which Col. C. Portway presided, Mr. C. H. Kain gave a Paper on "Metallography in the Iron Foundry," illustrating his remarks by numerous lantern slides. The attendance was 66 members and visitors. An interesting discussion followed, which included such topics as alloy additions, inoculation, annealing, and buying pig-iron by fracture or composition and microstructure, a useful contribution being made by Mr. H. H. Shepherd.

MR. KAIN, in replying to a vote of thanks, expressed his indebtedness to the Institute and the B.C.I.R.A. for the loan of slides, and to Lake & Elliott, Limited, of Braintree, for the use of apparatus.

LONDON AND SHEFFIELD JOINT MEETING

The joint meeting of the London and Sheffield Branches of the Institute of British Foundrymen, to be held to-morrow and on Saturday, in London, is to include a lecture on "Arc Welding as Applied to the Foundry Industry," by V. Gordon Pearson. Mr. Pearson lectures on behalf of the Sheffield Branch, and Dr. W. D. Jones, who represents London, is dealing with powder metallurgy.

New Companies

(From the Register compiled by Jordan & Sons Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

J. T. Price & Company (Brass & Aluminium Founders), Limited.—Capital £600. Director: P. Boulnois, Claremont, Park Avenue, Kidsgrove, Staffs.

Turkish Engineering & Construction Company, Limited, Granite House, Cannon Street, London, E.C.4.—Capital £1,000. Directors: I. N. Pamir and M. R. Teksan.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Inventions

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your editorial reference to my observation that the manufacture of chilled rolls is unique in having spread from one centre of origin to other countries, you proceed to criticise and then confirm my views! My theory is that most processes—the extraction of iron from the ore by charcoal, hardening by quenching and subsequent tempering, making iron castings, etc.—have been independently discovered in many ages in many countries.

Your own columns, for instance, have reported iron castings from China about A.D. 500 and old cannon from Europe in the 14th and 15th centuries without any connecting link.

The famous Wootz steel made 1,000 years ago, possibly, seems to have been crucible steel.

It is questionable if the Bessemer process you quote was not simultaneously or previously discovered by Kelly in the U.S.A.

Mathematical and chemical discoveries also have provided examples of independent discovery, but, so far as concerns chilled rolls, there appears to be good evidence of one centre of origin from which the process of manufacture spread to other parts. At all events, the Prussian Industrial Association in 1821 offered a prize for the production of chilled rolls, being a gold medal and 200 thalers ("Die Giesserei," January 18, 1935).—Yours, etc.,

A. ALLISON.

Holmes Mills, Rotherham.
November 21, 1938.

Catalogues Received

Refractory Materials. A very homely 16-page booklet has been received from the Midland Monolithic Furnace Lining Company, Limited, of 40, Humberstone Road, Leicester. For the benefit of our American readers, the reviewer would explain that the word "homely" is not used in the sense they employ. Rather is the word meant to imply that it reads like a fireside chat. It is entitled "Black Seam Super Refractories," and notes are given as to the uses of the "Mono" grade for rotary furnaces, cupolas, converters and the like—this actually represents a range rather than any one specific grade; the "plastic" grade is designed for patching cupolas and high-temperature cements. Hints are given as to methods of choice and application. This booklet is available to readers who write direct to Leicester, an action which is well worth while.

Pulverising Plants. Two leaflets have been received from the British Rema Manufacturing Company, Limited, of Highroad Well, Halifax, one of which deals with pulverising mills, including ball, pinned disc and pinned cage, hammer and ring-roll types and several other sorts of crushers and classifiers. The second one is devoted to pulverised-fuel firing plant and shows how some of the machines dealt with in the former pamphlet can be combined with burners to form an integral firing unit.

Ingot-Mould Metal

L. F. REINARTZ, in the course of a Paper on "Recent Development of Open-Hearth Processes in the U.S.A.," presented to the recent Autumn Meeting of the Iron and Steel Institute, states that in the United States the trends still seem to indicate that moulds made from direct blast-furnace metal give a slightly longer life than those made from cupola metal.

Principles of Gating and Feeding

THEIR APPLICATION IN PRACTICE

By A. M. CAMPBELL (G. & J. Weir, Limited)

(*Concluded from page 368.*)

Turbine Feed Pump Impeller

Figs. 11 and 12 show an example of another type of impeller to be cast in Monel Metal. In this case the centre boss is about 4½ in. diameter spreading out to 6 in. diameter where it joins the shroud. There is a further thickness of metal attached to this shroud for the packing ring as shown at AA in the sectional view (Fig. 11). The blades of this impeller are only $\frac{5}{16}$ in. thick, while the shroud is $\frac{5}{8}$ in. and the packing ring 1¼ in. thick. There is an extremely heavy section of metal at the boss.

If cast in the normal way as shown in the previous example of the extraction pump impeller (Fig. 9), shrinkage would occur at this heavy section. In order to overcome this the method of moulding was reversed so as to obtain risers over the centre boss and from the packing ring, as shown. Further, to avoid cracking and to give a more even heat distribution, two side gates cut at the parting were used; this arrangement gives direct access to all the blades, and has been found to be the most successful method of casting this type of impeller. Two hand ladles are required to cast these impellers at points GG (Fig. 11). The sprays used are of rectangular section 2 in. by ⅜ in., while the downgate is 2 in. diameter.

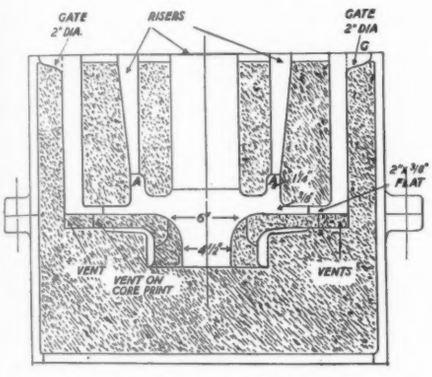

FIG. 11.—SECTION OF MOULD FOR FEED PUMP IMPELLER.

Gunmetal

The examples given under this heading were cast in Admiralty gunmetal of the following approximate composition:—Copper, 88; tin, 9.5 to 10; zinc, 1.8 to 2; and lead, 0.5 per cent. max. In dealing with the gating and feeding of this alloy, the main points for attention are:—(1) The sprays should be larger in area generally than required for cast iron; and (2) while risers are necessary to deal with liquid shrinkage in some cases, feeding is more or less regulated by the casting temperature.

There has been ample evidence of shrinkage cavities due to too low a casting temperature. There is a wide divergence of opinion as to the correct casting temperature, due possibly to the fact that various authors have in mind different kinds of castings and different foundry conditions. In the examples given the casting temperature range of the metal was 1,180 to 1,220 deg. C. This temperature range has been found most satisfactory for the author's type of work.

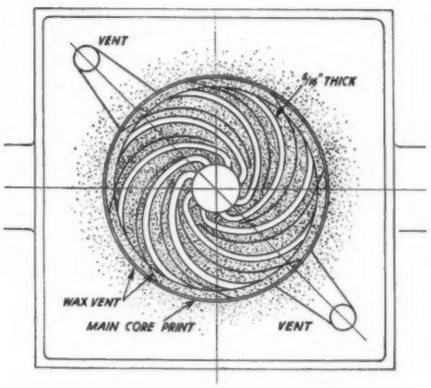

FIG. 12.—PLAN OF MOULD FOR FEED-PUMP IMPELLER.

Gunmetal Valve Body

Fig. 13 shows the section and plan of a valve body, fairly uniform in section. The manner in which this body is gated will serve to illustrate a clean and successful method which is typical of normal production in gunmetal and can with modifications be applied to numerous types of castings. As shown in Fig. 13, the metal enters the mould through flanges AA by two in-gates BB of the direct dirt-trap type, correctly proportioned, ensuring a flow of clean metal to the mould. Risers taken from the casting at the points shown overcome liquid shrinkage, feeding being governed by correct casting temperature.

Gunmetal De-Aerator

Fig. 14 is a plan and section of a mould for a large gunmetal de-aerator casting weighing approximately 2 tons, and of $\frac{7}{16}$ in. average thickness. On account of its size and section, the gating had to be considered very carefully, more particularly since internally the casting had a baffle box attached by ribs to the external contours of the casting. Arrangements had to be made to get the hot metal to this box as well as provision for casting the outside contours. The following arrangement was found to give satisfaction by avoiding a mis-run. Provision was made for casting with two ladles, one on either end of the mould. At A, Fig. 14, on the main core print, two channels were cut and each was fed by a main gate. Eight sprays were taken off these channels and entered the mould at flange X (Fig. 15).

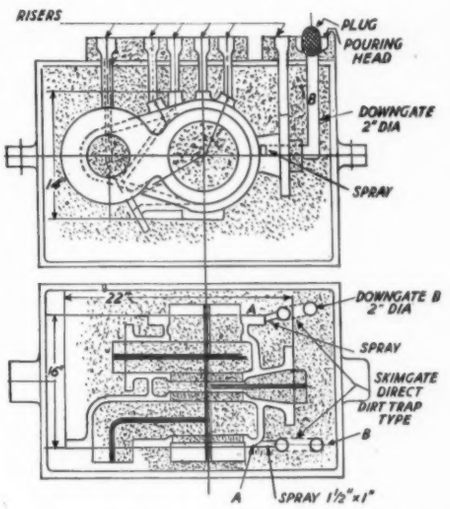

FIG. 13.—MOULD FOR VALVE BODY WITH $\frac{7}{16}$-IN. METAL SECTION.

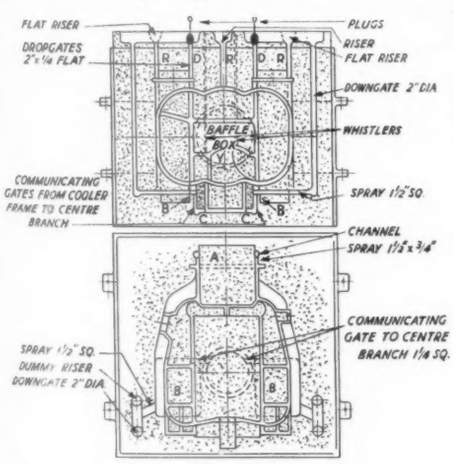

FIG. 14.—MOULD FOR DE-AERATOR CASTING, IN 8-FT. SQUARE BOX.

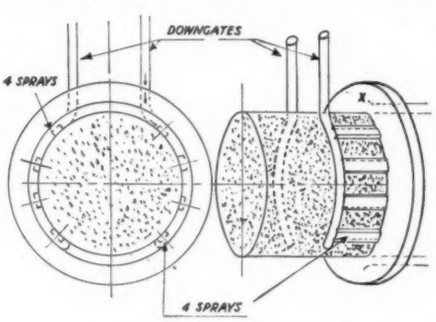

FIG. 15.—ARRANGEMENT OF SPRAYS FOR DE-AERATOR CASTING.

This arrangement did not succeed in getting the metal to the bottom of the mould, and it would have risen in the mould about 1 ft., and then tumbled back into the cooler branch, which is at the bottom of the mould, and might have caused cold shut. To avoid this the stool flange nearest this branch was connected by two sprays, as shown at CC, Fig. 14. These sprays were 1¼ in. sq. By this arrangement, immediately

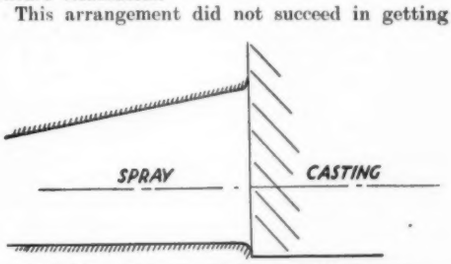

FIG. 16.—SHAPE OF SPRAYS FOR GUNMETAL.

the stool flange became full of metal, it was by-passed to the bottom of the mould. Finally, on top side of the mould four drop gates were used at DD, as shown in Fig. 14. These were so arranged to pass down the metal thickness of the top stools, which, in turn, was connected by ribs to the baffle box internally.

On casting, these gates were plugged, and gates at A and B started first. When it was judged that the metal had risen in the interior of the mould to the bottom side of the baffle box, *i.e.*, at Y (Fig. 14), these plugs were removed and hot metal allowed to drop on to the rising metal. These gates were 2 in. by ¼ in. Risers were taken off as shown at positions R, R, R, and whistlers, as shown by arrows in Fig. 14, in the box core to assist in eliminating any chance of an air lock in that portion of the casting.

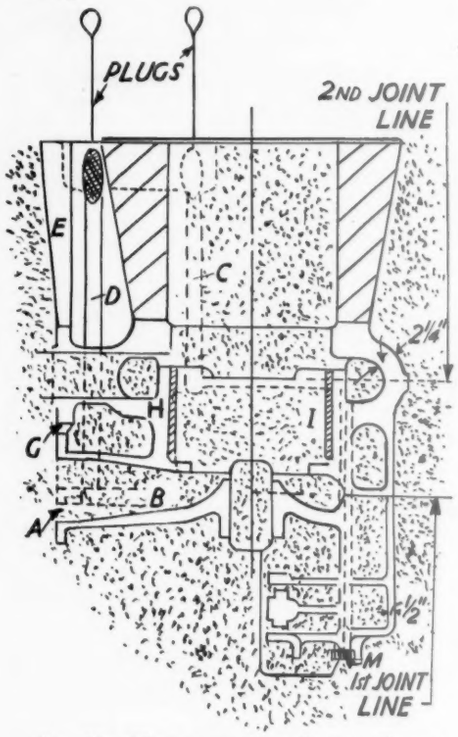

FIG. 17.—MOULD FOR HIGH-TENSILE BRONZE PUMP CASING.

High-Tensile Bronze

The alloys from which examples are given under this heading are made up approximately as follow:—Copper, 54 per cent.; zinc, 40 per cent.; iron, 1.7 per cent.; aluminium, 2 per cent.; and manganese, 2.8 per cent. The tensile strengths in the as-cast condition are in the region of 38 to 42 tons per sq. in., with an elongation of 20 to 28 per cent. This alloy has an extremely high liquid shrinkage, and on this account heavy risers or feeding heads are required. Gating has to be such that as little turbulence as possible occurs when casting. This turbulence causes the formation of zinc oxide which, like sand, is highly refractory, and forms an inclusion to the detriment of the casting. Sprays, therefore, must be situated at the lowest point of the casting and shaped as is shown in Fig. 16 to obviate "fountain" effect. Casting temperature is also important for the same reason as with gunmetal. The most satisfactory casting temperature range for this metal, in the author's experience, is 980 to 1,020 deg. C.

High-Tensile Pump Casing

Fig. 17 shows a section through the assembled mould and cores of a turbine pump casing in high-tensile bronze. This pump has an oil box with bearing attached to the main pump body. The average section is about ½ in., while the pump itself varies from 2-in. to 3½-in. section. On account of the high shrinkage of the metal the pattern was made so that the heavy pump sections were on the uppermost portion of the mould. The oil box was arranged at the bottom.

A gate C was formed as shown in Fig. 17 (section of mould) and Fig. 18 (view of finished casting) and stepped down gradually from the second to the first parting, finally to enter the mould by a spray at the flange in the bottom of the oil box at M. This gate was 2 in. in diameter. After stepping down the first parting it was reduced to 1¼ in. diameter, while the spray was 2 in. by 1 in., opening out to 2¾ in. by 1¼ in. A further gate D was stepped down through the second parting to the first and finally two sprays were taken at a tangent to the lower portion of the pump body, as shown at A and B, Fig. 18. This gate was 2½ in. diameter to second parting, then stepped down to 2¼ in. diameter, with two sprays 2 in. by 1 in., increasing to 2¾ in. by 1¼ in.

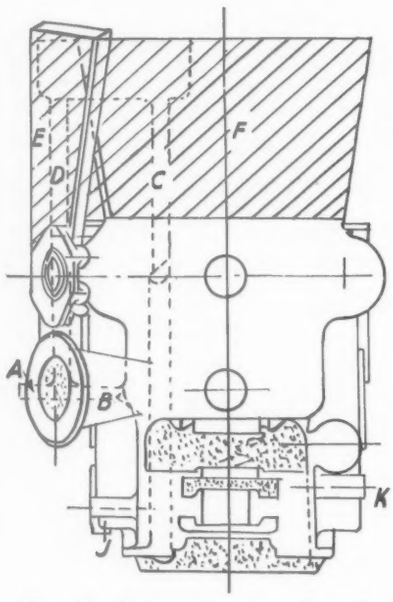

FIG. 18.—REPRESENTATION OF PUMP-CASING CASTING.

The total depth of casting was about 3 ft. 6 in., and a head of 2 ft. was found necessary, as shown at F in Fig. 18. In addition, a riser was taken from the discharge branch as shown at E. This branch was, in turn, connected to the suction branch immediately below, as shown at G. This overcomes the high shrinkage which occurs after casting. When casting, both main gates were plugged until the runner head was filled. While still pouring, the plug on the downgate C was withdrawn and the metal allowed to rise in the mould to the first parting. When this was judged to be the position, the second plug for gate D, Fig. 18, was withdrawn and metal allowed to enter sprays A and B, and casting was continued until the head was filled. About 2 tons 10 cwts. of metal was required to cast this pump—35 cwts. for the pump and 15 cwts. for head and risers. The gates were stepped as described in order to have as little turbulence as possible. In addition to the feeding heads described, denseners (or chills) were necessary to overcome shrinkage at points H and I, Fig. 17, and J and K, Fig. 18.

Three-Throw Pump and Valve Box

Figs. 19 to 22 show the top box plan, mid-section, plan-section, and cross-section of a three-throw pump and valve box which was cast in high-tensile bronze. Originally, this casting was made with cores, as shown in Fig. 21, directly through the cylinder and valve with chills as marked at the heavy flange side of the cylinder, to overcome the shrinkage which occurred at the junction of the metal between this flange and the cylinders, *i.e.*, X, X, X.

One gate was stepped down to the bottom of this heavy flange, as shown at A, Fig. 20. This gate was 2½ in. diameter, and stepped down at parting to 2 in. diameter with a spray in flange 2 in. square opening to 2¼ in. square. A second gate B was stepped down to the top end but at the opposite side of this heavy flange, and was also 2½ in. diameter, with 2-in. square sprays opening to 2¼ in. square. A third gate D was taken to the parting, thence direct to the valve box flange, and this was also 2½ in. diameter, with 2-in. square sprays opening to 2¼ in. square. Risers were taken off flanges E, E, E, whilst the valve box and main heads were taken from top of cylinder, *i.e.*, H, H, H (Fig. 20).

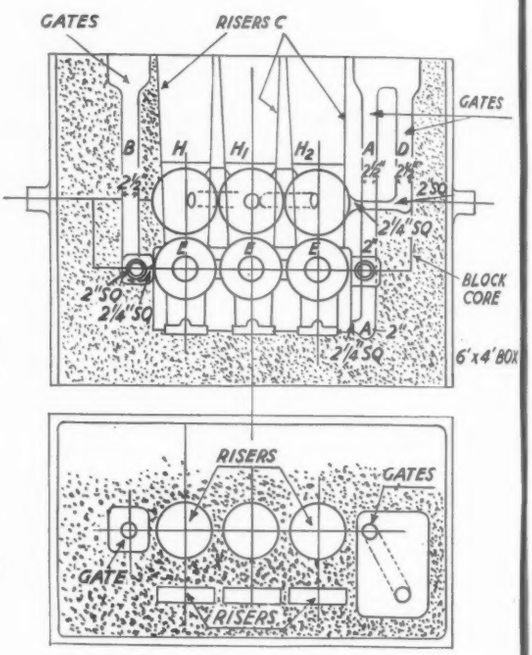

FIG. 19 (BOTTOM).—TOP BOX PLAN OF MOULD FOR HIGH-PRESSURE PUMP.

FIG. 20 (TOP).—MID-SECTION OF MOULD.

Originally the section varied from ½ in. to 2¾ in. at the junction of the cylinders and heavy flange at the bottom of casting as cast. When the casting was made by means of centre cores, Fig. 21, and chilled as previously described, trouble was experienced with shrinkage at points X, X, X all down the junction of the cylinder and the heavy flange. To overcome this, these centre cores were finally removed and the casting made solid, with the exception of the pipe connection core as shown at P, P, P. By so doing the shrinkage trouble was overcome and successful castings were obtained which withstood 2,500 lbs. per sq. in. water pressure. This casting finally required 3 tons of metal to cast, care being taken that the temperature was in the region of 1,000 deg. C.

In conclusion, the author desires to thank the directors and foundry management of G. & J. Weir, Limited, for affording him the facilities to produce and publish this Paper, and also to Mr. Fred Howell for his help in preparing the sketches for reproduction.

DISCUSSION

The CHAIRMAN (Mr. Evan J. Ross) said that they would realise why Mr. Campbell had been awarded the John Surtees Gold Medal for his Paper. He had dealt clearly with all the theories

of gates and risers and the applications to practical work. He was to be congratulated on the Paper and on the manner of its presentation.

MR. J. LONGDEN said the author had tried to correlate all theories to principles. They often heard statements of practice without reference to principles. Nearly all the illustrations were of special types of castings, and many particularly concerned non-ferrous work. These examples were exceedingly useful. In reference to cast iron the author had stressed the value of the trap gate, but the speaker doubted whether it was advisable in all applications. There was one principle with which he agreed in regard to the relative gate area, *i.e.*, the ingate should be 50 to 75 per cent. of the downgate area. He

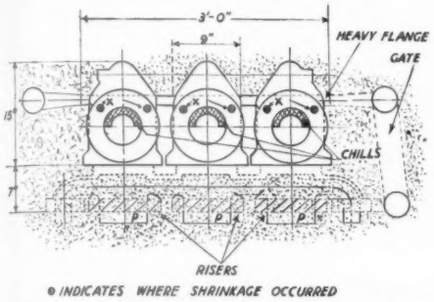

FIG. 21.—PLAN-SECTION OF MOULD FOR PUMP CASTING.

thought, however, that in green-sand work there would be too great a cutting action where the metal impinged on the mould. Mr. Campbell had very properly drawn attention to the necessity, in non-ferrous work, to arrange for the opening of the gate to avoid turbulence. Mr. Longden had been very interested in the remarks on making runners and the method of by-passing runners, but he noticed in some of the illustrations that the ingates were cut from the runner at a very awkward angle to the casting.

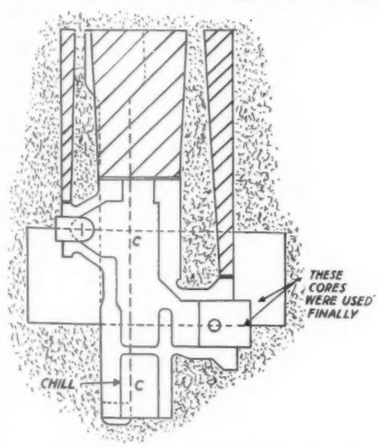

FIG. 22.—CROSS-SECTION OF MOULD FOR PUMP CASTING.

In one case the ingate gave the metal impact on the opposite side of the flange; but probably that was a mistake in drawing.

The CHAIRMAN said that he had had Mr. Campbell's experience in regard to the light castings industry, where it was paramount to get clean castings. He sketched several types of runner which he had used with success. He agreed with the author that the downgate must be greater in area than the runner.

MR. CAMPBELL thanked Mr. Longden for his kindly criticism, which was what he wanted. He himself was only a very young member; it was somewhat of an ordeal to read the Paper, and little did he realise that he could speak to the old and experienced members on such a subject.

The CHAIRMAN said that the members had been delighted with the Paper.

Some Defects of Iron Castings*

By J. L. SMITH, JUNR.

The purpose of this Paper is to discuss some of the faults which detract from the general soundness and surface perfection of a casting, rather than the faults due to insufficient mechanical strength. Although this latter is of great importance, it depends largely on the chemical composition, cooling rate and treatment given to the casting.

The defects of iron castings can be divided into three groups, namely:—(*a*) External or surface defects; (*b*) internal defects, and (*c*) cracks.

Surface Defects

The first and possibly most common of surface defects is the gashole. This term is usually applied to a hole which has been formed either by gases penetrating the surface of the metal, or gases coming from the metal itself. For the purpose of this Paper it is proposed that the former be designated by the term "external gashole," and the latter by the term "internal gashole." External gasholes will usually be found on the surface of a casting in clusters or in places where there has been an overhanging section of the mould. In appearance this type of hole would not be very distinctive. A person examining a casting and finding holes in its surface would have to decide more from the position than the appearance of the holes whether or not they were true external gasholes. An external gashole will not be found very far under the surface, because these holes are caused by gases penetrating the surface and the metal solidifies from the surface towards the centre.

The cause of an external gashole is, as has been said, the penetration of gas *into* the surface of the metal. Therefore, the gas can only have come from the mould itself. Generally speaking, there are two types of gases which can come from a mould. These are: (1) Steam caused by moisture in the mould, and (2) carbonaceous gases caused by the presence of carbon or "blacking" in the moulding sand, or an unnecessary thickness of blacking on the surface of the mould. A personal belief is that there are two possible ways of ridding oneself of this trouble.

(1) On coming up against the difficulty of external gasholes the first question one asks is whether the moulds were dried properly. The obvious solution is to increase the intensity of drying. By this is meant not necessarily an increase in the drying temperature, as this may lead to "burning" of the mould, and so a loss of permeability, but rather an increase in the drying time, or in some cases a change of method. Drying by means of a continual blast of hot, dry air, is the best method. Another, which is used a great deal, but which is not nearly so efficient, is that of drying over a coke fire. This method may only succeed in driving the moisture well into the mould and not succeed in eliminating it.

(2) There is, of course, a second way of looking at the question. Providing the mould is of sufficiently high permeability and is properly vented, no matter what gases are formed, they ought to be able to escape. Therefore, if the moulder has done his work properly and has seen to it that no denseners, mould-strengthening grates and similar articles used in moulding are in such positions as to stop the escape of gases, then the permeability of the sand itself must be looked to. This can be improved by increasing the grain size of the sand, or the addition to the sand of some substance which will burn out and leave minute holes. If this latter method is used, a coarse and well-vented backing sand is esential.

* Prize entry in a Short Paper Competition organised by the Newcastle Branch of the Institute of British Foundrymen.

Internal Defects

A type of surface defect classified under this section might be a surface pitting due to an excessive sulphur content. For ordinary grey cast irons a sulphur content of 0.120 per cent. is perfectly safe, but if the percentage is much above this, say, 0.150 per cent. or more, there is the danger of sulphide segregation in thick sections, and as sulphides are easily decomposed by heat, sulphur dioxide gas may be formed while the metal is still in its pasty stage. This gas then rises to the surface and causes a surface pitting.

The internal gashole is so designated because the gas comes from the metal itself. In appearance these holes may not differ very much from external gasholes, but if they are present their position on the casting will decide their classification. Internal gasholes will probably be found all over the surface of the metal, and also definitely trapped in the metal itself. These holes are usually caused by the gases evolved when a metal is oxidised. This may be the case when a large quantity of steel has been used in the charge. It can occur quite easily in cupola-melted irons. The fault can in most cases be overcome by the addition of a suitable deoxidant to the metal. For example, ferro-silicon, ferro-manganese and aluminium are all deoxidants.

Under this heading there is also sponginess, which is very often encountered in large, thick sections of metal. This is due to the contraction of the metal on cooling down. It can be averted by feeding the still molten metal by means of iron rods, and in cases where the section is very large an extra quantity of hot metal may be added and feeding continued. Care must be taken, however, not to feed the casting too long. If the feeding be taken too far into the pasty stage, trouble may be encountered in the form of actual holes left by the feeding rods. The cause of this is as follows:—When the metal is becoming pasty and a feeding rod is forced into it, the rod makes a hole into the metal. On the withdrawal of the rod, the pastiness of the metal prevents it filling up the hole, and some air may be trapped. Again, the pastiness of the metal prevents the air from escaping, and so a hole is formed. It is analogous to the effect obtained when a pile of wet cement is probed with a walking stick.

Cracking

The first consideration is the straightforward crack, which is usually found to occur in places where a change of section takes place in the casting. A crack is largely due to the differences in cooling rate, and thus the rates of contraction of thin and thick pieces of metal. There are one or two fairly obvious ways of overcoming the difficulty. The first is to introduce denseners into the mould at the thick section to produce a partial chilling effect, which increases the cooling rate of the thick section to be comparable with that of the thin section. The second method is, where possible, to alter the shape of the mould so that the change from thin to thick sections is more gradual.

A crack may not always occur through change of section. It may occur through one part of the casting being held too firmly in the mould so that there is a counter-force to the force of contraction set up. This may lead to cracking. Again, the metal might crack through being too hard where the cooling rate is too quick and the section too large. This can be overcome by the use of a softer metal.

In a consideration of cracks, it may be possible to include the "draw," which is, in effect, a partially formed crack, and may be formed and treated in much the same way as a crack.

Some foundrymen will no doubt have very divergent opinions on the matters discussed in this Paper, but the opinions set down will at least present a little food for thought.

Canadian Iron and Steel Industry

A REVIEW OF ITS GROWTH AND DEVELOPMENT

An outline of the growth and development of the Canadian iron and steel industry is included in Report No. 128, "Iron and Steel," issued by the United States Tariff Commission, being a survey of the iron and steel industries and international trade of the principal producing and trading countries, with particular reference to factors essential to tariff considerations.

History and Economic Position of the Industry

The manufacture of iron and steel in Canada in significant volume began in the latter part of the nineteenth century. Although coal and iron ore were discovered in the Maritime Provinces as early as 1604 and the first blast furnace was built in 1737, little was accomplished during the next century toward establishing an iron and steel industry. A few plants were active in 1830 when small quantities of pig-iron, bar iron, and iron castings were produced, partly for exportation. Bounties paid by the Canadian Government encouraged the production of pig-iron during the period 1883-1911 and similarly stimulated steel production during the years 1896-1913. Because of growing opposition, the Government in 1910 decided not to renew any bounties. Between 1883 and 1913 the Dominion Government paid out more than $17,000,000 in iron and steel bounties, of which more than $14,000,000 was in the years 1903-11.

The growth of the industry during the first two decades of the present century was rapid, production of steel ingots and castings increasing from about 20,000 tons in 1900 to over 1.5 million tons during the later years of the war. After 1920, production fluctuated with economic conditions; in 1936 it was 1.1 million tons, and in 1937 about 1.4 million tons, or somewhat more than in 1929. In 1936 the number of employees engaged in the iron and steel industry proper averaged 11,138, and their total salaries and wages amounted to about $13,800,000. Notwithstanding the expansion of the Canadian iron and steel industry during the present century, it has been unable to satisfy the increasing domestic demand. In consequence, Canada is a large importer of iron and steel products, ranking seventh among the importing nations. The proximity of large producing centres in the United States to industrialised sections of Canada, particularly in the Great Lakes area, places the United States in an advantageous position to supply the Canadian market.

Organisation of the Industry

The iron and steel industry of Canada had a capital investment of $92,000,000 in 1936. The major plants are located in Ontario, Nova Scotia, and Quebec. Four produce pig-iron; of these, three, with seven blast furnaces, are in Ontario, and the other, with three blast furnaces, is in Nova Scotia. The 10 furnaces have an annual capacity of nearly 1.6 million tons of pig-iron. At the end of February, 1938, six furnaces (64 per cent. of capacity) were active, and four (36 per cent. of capacity) were idle. The plant in Nova Scotia uses local coal and brings iron ore from the Wabana deposits on Bell Island, Newfoundland, which it controls; the Ontario works are dependent upon coal and iron ore imported from the United States. Three of these producers of pig-iron also operate steel-works and rolling mills. There are a number of smaller concerns which are integrated to a lesser extent in that they have no blast furnaces. The Canadian plants have an annual capacity of 1.9 million tons of steel ingots and castings and about 1.6 million tons of finished hot-rolled products.

The productive capacity of each of the principal companies in relation to the total for the Canadian iron and steel industry is shown in Table I.

TABLE I.—*Capacity of Principal Iron and Steel Companies in Canada*, 1936.

Company.	Number of blast-furnaces.	Annual capacity in long tons.		
		Pig-iron.	Steel ingots and steel for castings.	Finished hot-rolled products.
Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario ..	4	675,250	540,000	425,000
Dominion Steel & Coal Corp., Sydney, Nova Scotia ..	3	450,000	400,000	332,700
The Steel Co. of Canada, Ltd., Hamilton, Ontario ..	2	340,000	640,000	441,800
Canadian Furnace Co., Ltd., Port Colborne, Ontario ..	1	102,680	—	—
All other companies	—	—	334,000	361,250
Total	10	1,567,930	1,914,000	1,560,750

Plant realignments of considerable proportions were undertaken in Canada in 1935-36. Mills producing structural steel and rails were rearranged to permit production of a more diversified list of rolling-mill products. Equipment was installed to supply the increased demand for materials for railway rolling stock as well as for public works. By the end of 1936 tin-plate was being made by the Dominion Foundries & Steel, Limited (Ontario), which was reported to have spent nearly $1,000,000 renovating its plants.

Raw Materials for Pig-Iron Industry

The blast-furnace industry is dependent very largely upon imports for its raw materials. Although extensive deposits, widely distributed, have been discovered from time to time, iron ore is produced in Canada in only very small quantities. The actual reserves are estimated at about 200 million tons. In Ontario, Quebec, British Columbia, and in the St. Lawrence Valley there are fairly large deposits, but the ore is usually so inaccessible or so low in grade as to render mining operations impracticable. Efforts are being made, however, to exploit certain of these deposits. The Algoma Steel Corporation estimates that its New Helen mine near Sault Ste. Marie has ore reserves of more than 100 million tons containing from 30 to 35 per cent. iron. There are large and accessible supplies of high-grade ores at Wabana, Newfoundland, the actual reserves of which are estimated at 4 billion tons. In Ontario, where the iron and steel industry is largely concentrated, high-grade iron ore is readily available from the Mesabi Range of Minnesota, and coal from the Appalachian fields of the United States.

In 1935, 50 per cent. of the imports came from the United States and 46 per cent. from Newfoundland. In 1936, the share from the United States increased to 57 per cent. and in 1937 to 67 per cent., whereas that supplied by Newfoundland declined.

Although Canada has reserves of coal which are adequate for its present and prospective needs, they are so located that it is more economical to import a large proportion of the requirements, especially for the central provinces. Coke is also imported, but the ratio of imports to consumption is much lower than for coal. Only a small part of the coal and coke consumed in Canada is utilised in the manufacture of iron and steel. During the period 1929-36 Canada imported about one-half of the coal and one-fourth of the coke consumed for all purposes. Canada exports only small quantities of coal and coke. About 85 per cent. of the coal and 95 per cent. of the coke imported into Canada come from the United States. The United Kingdom supplies most of the remaining imports.

Pig-Iron and Steel Output

In 1913 Canada was dependent upon foreign sources for about 17 per cent. of its requirements of pig-iron, but since that time the country has become practically self-sufficient and since 1932 has been on an export basis. Annual production in 1913, from 1916 to 1918, and in 1928 and 1929 was slightly in excess of 1 million tons. After 1929 production declined to about 145,000 tons in 1932, but since then has steadily increased, and amounted to 898,000 tons in 1937.

Canadian production of steel ingots and castings reached a peak in 1929, but declined considerably in the next three years. By 1934 there was a notable improvement, and in 1937 production attained the 1929 level, about 1,400,000 tons. In 1913 the Bessemer process accounted for over one-fourth of the total production, but in recent years none has been produced by this process; on the other hand, production of steel ingots and castings by the open-hearth process increased from 74 per cent. of the total in 1913 to 93 per cent. in 1937.

TABLE II.—*Finished Iron and Steel: Output in Canada, by Type of Product* (Thousands of long tons).

Year.	Hot-rolled iron and steel products.				Advanced iron and steel products.					
	Rails.	Structural shapes and wire rods.	Plates and sheets, merchant bars, tie-plate bars, etc.	Total.	Forged.	Splice bars, tie plates, etc.	Wrought-iron and steel pipe.	Cast-iron pipe and fittings.	Wire and cut nails.	Total.
1929	383	186	502	1,071	29	79	134	72	58	372
1930	233	142	396	771	17	55	103	72	45	292
1931	140	117	279	536	14	38	67	81	37	237
1932	45	91	123	259	7	9	33	33	32	114
1933	68	105	143	316	5	5	34	13	34	91
1934	97	199	299	595	7	19	50	12	47	135
1935	109	223	410	742	8	24	55	14	46	147
1936	116	253	497	866	8	29	62	18	51	168
1937	77	270	713	1,060	18	27	83	27	59	214

The peak of Canadian production of hot-rolled iron and steel products was reached in 1929 (Table II). The ensuing years showed a decline, but after 1932, production increased steadily. Although total production in 1937 was less than in 1929, that of some products, both hot-rolled and further advanced, was greater than or about the same as the output in 1929. Production of rails and pipe, however, was far less.

What We Do Not Know About Cast Iron*

An Address by J. E. HURST (Past-President, Institute of British Foundrymen)

I have had no choice in the title of this lecture. I received a characteristic letter from Mr. Faulkner informing me that this title had been put forward as a suitable subject for a lecture, and that he thought I ought to deal with it, and I had not the heart to refuse. The situation in which I find myself, however, is very much like that of the unfortunate student in the examination room expecting to find a list of alternative subjects from which to choose one for his essay in English composition, and finding instead one and one subject only, and that one about which he must know nothing.

The title at a superficial glance might appear to be an attractive one with which to deal, and it is true to say that it has been a refreshing experience to me to sit down and consider the subject, cast iron, from this point of view. The title is, however, very broad. Obviously I cannot attempt to speak for everybody, and all that I can attempt to do really is to speak about the things that I do not know myself about cast iron. Even this more restricted title is by no means easy to deal with. The secretary asked if I should need a lantern, and as I had no photographs of the many and various things about cast iron which I do not know I had to reply in the negative.

There is, of course, so much that I do not know about cast iron that my greatest difficulty is to decide how best to review the matter in the space of a single lecture. In this respect the very breadth of the title is not helpful. I might be justified perhaps in dealing with the costs of castings. Our Costing Committee, or at any rate many of its individual members, tell us we know nothing about the costs of castings. I have heard it said that our knowledge of the statistics of the cast-iron industry in this country is not as good as it might be, and this might legitimately be dealt with under the title as it stands. On the other hand, I might even invert the title and try to tell all that I do know about cast iron, finishing up by the suggestion that what I have had to leave untold is what I do not know about the subject. Q.E.D.

Problems Investigated Provide Study Basis

A bare recital, in a more or less tabular form, of the multitude of things that are still unknown in connection with this subject would be a very clever way of dealing with this subject if it could be done. I venture to think that this would be a most uninteresting method of dealing with it as a lecture. Every metallurgist and foundryman on many occasions must have been called upon to investigate problems which have arisen in connection with cast iron. I am quite sure that he must be able to number amongst these—if he is honest with himself—many which he never satisfactorily solved. If he desires to study what is not known about cast iron a review of such unsolved problems will provide him with much food for thought. It did cross my mind to attempt to deal with this subject somewhat on these lines and whilst for a number of reasons I had to abandon the idea I throw out the suggestion as a useful basis for the individual consideration of this question.

I suppose, however, that the immediate wishes and desires of the Branch will be gratified if I manage to deal with the subject in such a way as to stimulate a good discussion. With this end in view I propose to select a number of things about which I myself know very little and attempt to discuss them with a view mainly to showing their importance. In order to cover as wide a field of interest as possible the details I have selected can be divided broadly into two classes, *viz.*, the class which can be defined strictly as metallography or matters relating to constitution, and the other class which may be described as practical, in that the details will be concerned with the practical manufacture and the industrial use of cast iron.

The Formation of Graphite

In all cast-iron alloys the feature of the constitution of greatest importance is that of the formation of graphite. In one way or another the whole of the properties and indeed the industrial importance and value of cast iron turns upon this feature of its constitution, *viz.*, the presence or absence of graphite and its form and distribution. The phenomenon of graphitisation still remains very complex and but imperfectly understood. In this phenomenon there still lies wrapped up a tremendous amount of "what we do not know about cast iron." It is perhaps true to say that the difficulties in understanding graphitisation in cast iron have been responsible for the maintenance of continued interest, and the study of this phenomenon has by no means abated; on the contrary, it is being vigorously pursued by metallurgists throughout the world and in particular by our own British Cast Iron Research Association. New light has been brought to bear on the subject through the better understanding of the crystal structure of iron-carbon alloys arising out of the developments of X-ray examination; by the study of the effects of superheating; the investigation of the conditions controlling the size and refinement of the graphite; and the discovery of the effect of particles of undissolved impurities and dissolved gases which may exist in the cast iron. Whilst the investigation of these phenomena is being pursued strenuously, we can realise readily that a tremendous amount of what we do not know about cast iron will be answered when we know such things as the magnitude and nature of the undissolved impurities, more about the nature and quantities of the dissolved gases.

I should like to take this opportunity of drawing attention to the extremely important part played in these studies of graphite formation by the improved technique in the microscopic examination of cast iron. The importance of this is often overlooked, and, in fact, during the last few years there has been a remarkable improvement in this direction. This is not due to any startling epoch-making improvement in apparatus, but more to improvements in manipulative details and skill in examination. In my view, this change is due entirely to the British Cast Iron Research Association and the standard of excellence set and persistently maintained by their work. This has not only been responsible for the general all-round improvement, but has undoubtedly had a marked influence in the development of our theoretical conceptions.

In discussing the subject of the constitution of cast iron from this point of view, we are all well aware of the fact that cast iron as we know it is by no means a simple binary alloy, but much more complex, containing normally at least four more constituents—silicon, manganese, sulphur and phosphorus. It will serve my purpose if I remind you that there still remains a good deal that we do not know regarding the mode of existence of these additional constituents and their effect on the constitution of cast iron. As regards still further additional constituents which we now regard as alloy additions, we have, of course, accumulated a considerable amount of knowledge, but this only serves to remind us how much we do not know about their influence. Any chemist can quite easily select the names of a number of elements about whose influence on cast iron we know next to nothing, and who knows whether or not the influence of any of these yet untried elements may not profoundly affect the properties of cast iron? For example, the addition of the comparatively rare elements tantalum and niobium have already been found to have a marked influence on the nitrogen hardening properties.

Gas-Free Cast Iron?

What is the nature, character and properties of cast iron completely free from dissolved gases and from insoluble particles of slag is a question that is difficult to answer. Even yet our knowledge of the pure binary iron-carbon alloys is distinctly limited, and obviously cannot be overlooked in an address of this kind.

Whilst still on the subject of constitution, I can mention that the study of segregation phenomena in connection with cast iron is one that has been somewhat neglected, and about which we know very little. In connection with steel, a good deal of work has been done in this direction, perhaps because it is of greater industrial importance than in the case of cast iron. It has, however, proved of value in helping to understand the mechanism of solidification of steel, and I have often felt that similar investigations in the case of cast iron would prove equally helpful. In any event, we must number many aspects of the phenomena of segregation amongst the things we do not know about in connection with cast iron. Incidentally, studies of this nature might prove of great industrial value, particularly in connection with the production and service behaviour of large rolls and castings of similar magnitude and importance. I have never seen any studies of the surface character and composition of rolls, and yet our knowledge of the nature of solidification would lead us to surmise the possibility of differences which might be of considerable importance.

I might continue with other aspects of the constitution of cast iron about which metallurgists could bear to know a great deal more. Perhaps some of these might be regarded as belonging to the higher realms of physical metallurgy or metallography as, for example, the nature of liquid cast iron. I think all metallurgists feel that our conception of the nature of liquid alloys, particularly cast iron, is lacking in many directions, *e.g.*, the condition of the carbon, the effect of temperature, and perhaps the next few years will witness an improvement in our knowledge in this direction. I feel for the purposes of this lecture it might be more useful to pass on to the consideration of a few points which lie nearer to the hearts of practical men.

Heat-Treatment

I have chosen heat-treatment as a subject from which I feel I can draw a few examples of what we do not know about cast iron. It is now well established that cast irons can be hardened and tempered as in the case of steels. Whilst the utility of such treatments has been well understood for quite a long time in the case of steels the knowledge of their effect on cast iron is quite recent and due entirely to modern research work. Modern investigations show that when suitable cast irons are subject to hardening treatment by heating to temperatures above the A_1 critical point and quenched in water or oil an increase in hardness accompanied by a marked drop in tensile strength results. Tempering the quench-hardened specimens is accompanied by a recovery in ultimate breaking strength, and all investigations show that this

* Given to the London Branch of the Institute of British Foundrymen, Mr. C. C. Booth presiding.

recovery increases uniformly with increasing tempering temperature until a maximum is reached, followed by a decline with still further increment in tempering temperature. The magnitude of this recovery in strength value can be very large, according to the composition and character of the original material, and strength values quite 50 per cent. greater than the original "as-cast" value have been recorded. In fact heat-treatment of this nature is now to be classed as one of the means of improving the strength value of cast-iron alloys and of course is in regular use in certain sections of the cast-iron industry.

In connection with this matter a tremendous list can be made out of things we do not know. It is true to say that we do not know anything like so much about the metallography of the changes due to hardening and tempering as we do in the case of steels. For example, what part is played by the graphite? What exactly happens to the graphite? Some of the graphite dissolves—does it leave spaces? These are only a few of the questions that can be asked and which are still by no means easy to answer. A characteristic feature of a hardened cast iron lies in the fact that it loses its metallic sound and steadily recovers it on tempering. Can anyone explain why? Again, in connection with centrifugally-cast cylinders, hardening and tempering invariably reverses the character of the internal stress and the original character is steadily restored with increasing tempering temperature. Again, I submit the reason for this is still to be classed amongst the things we do not know about cast iron, and more knowledge of this matter will prove of value in heat-treating complicated articles. In my own experimental work in connection with heat-treatment by hardening and tempering, I have encountered phenomena which I consider are akin to the impact brittleness or temper brittleness in steels. I still know very little about this, but obviously a study of the matter may lead to improved heat-treatment procedure as in the case of steels. Whilst I have had only a little to do with malleable cast iron, I feel I ought to refer to the lack of knowledge of the effect of further heat-treatment for such purposes as refining the grain structure. Here again, in some of the experimental work on alloy malleable cast iron that has been carried out, I have hoped that some light might be thrown on the problem of temper brittleness.

The discovery and application of other forms of heat-treatment to cast iron still remain a possibility. The application of the nitrogen-hardening process is a case in point, and whereas this and the flame-hardening method, such as used in the Shorter process, have been developed as means of surface hardening cast iron, it can be truthfully said that we know very little about other methods of case-hardening applied to cast iron.

To Bend Cast Iron

During the preparation of my notes for this lecture I asked one of my friends the question "What do we not know about cast iron?" His reply was very prompt and was "We do not know how to make it bend." I suppose the search for a method of making cast iron bend dates back to the very early days of the cast-iron industry. This was the Philosopher's stone of the early cast-iron metallurgists, and perhaps still is. During the wave of development of cast iron in this country towards the latter end of the eighteenth century so enthusiastic were the ironfounders of this time that they did not hesitate to extend their developments of the application of iron castings into the realm of cutlery. This caused the cutlery trade great concern. Prohibition of the manufacture of table forks from cast iron was attempted by law as early as 1780, and a further act to regulate the cutlery trade was passed in 1819. This situation encouraged the very early attempts to make cast iron bend, and thus more resemble steel or iron, and the early experiments of Samuel Lucas in 1792 and 1804 had this object in view. It is well known that his brother, Thomas Lucas, took up this process for the production of cutlery and edge tools, which in the words of a writer of that time "would take as fine a polish and as fine an edge as articles of the best cast steel."

I have a pair of scissors in malleablised cast iron produced about 1820. As we are dealing with what we do not know about cast iron it is of interest to note the polish on these. This serves to remind us how little we know of surface films.

It is true to say that this search for a method of making cast iron bend resulted in this country in the development of malleable cast iron. To point to malleable cast iron as cast iron which will bend would not be a sufficient answer to my friend. I am quite sure that what he considers we do not know is how to produce cast iron direct in the form of castings which will bend without the difficulties of the white iron stage and perhaps without the difficulties associated with the annealing treatments. Perhaps the modern so-called pearlitic malleable castings are in part an answer, but I am sure metallurgists will continue in their hope that, as temper carbon is apparently so little different chemically from graphite, bendable cast iron may be produced still more directly.

Strength Properties

Mention of the production of malleable cast iron and cast iron that will bend leads me to consider various aspects of the strength properties of which we know very little. Much attention has been given to the ultimate breaking strength, and it is true to say that modern research work has made possible the production of irons having very substantially improved strength figures. In the early nineties—the naughty nineties!—a competition was organised at Woolwich Arsenal and several hundred specimens of high quality irons were examined. The best results obtained were a little over 15 tons per sq. in. and the worst a little over 4 tons per sq. in. tensile strength. If a similar competition were organised to-day it is certain that the best result would be at least double, as we know that 30 tons per sq. in. can be obtained. In reviewing the changes that have come over the metallurgy of cast iron during recent years the outstanding impression that I derive is the steady growth in the realisation that cast irons—as a group of alloys within the wider field of ferrous alloys—possess a wide range of physical and mechanical properties peculiar to themselves and of well-defined economic value.

It is now realised that cast irons, for example, really do possess elastic properties, and these properties are put to useful purpose and enter into considerations of the uses of cast iron for such things as piston rings, valve seat inserts, cylinder liners and other applications where cast-iron parts are required to withstand interference fits. This involves a knowledge of the modulus of elasticity, the permanent set and plastic deformation, and elastic hysteresis. What are the conditions governing these properties? How does one set about meeting a specified limit of modulus of elasticity, for example? What are the conditions of composition, structural character, etc., which influence modulus of elasticity? This is a subject about which we know little, and those of us who have had to deal with these properties have been very much in the dark and still feel that we have a great deal to learn. We now talk about the fatigue limit and endurance range, the creep limit, the acoustic and damping properties, and I am afraid that even the most learned amongst us will agree that we know very little about them in detail. There are, of course, other physical and mechanical properties, thermal expansibility and conductivity, electrical and magnetic properties, and whilst of late years the store of our knowledge of these properties in connection with cast iron has increased considerably there is still a great deal more to be learned.

Internal Stress and Camber

Internal stress, frequently referred to as casting stresses in castings, I have mentioned earlier on in connection with heat-treatment. This is quite a troublesome feature in several sections of the ironfounding industry, and must be included in any consideration of what we do not know about cast iron. I am sure this is a subject in which there is room for plenty of investigation. It touches the practical worker in cast iron in many ways. In white iron castings the difficulties and mysteries associated with premature cracking are well known. They are attributed to the pig-iron and the weather, and I even have a record of a case of a certain white iron casting which it is claimed can only be made in France. In this case the actual iron used in France has been brought over to this country and, when tried here, resulted in castings which "fled," the conclusion being drawn that France is the country in which to make these castings. Camber in castings may be referred to in connection with internal stresses, and I think most practical foundrymen can set the metallurgist many unanswerable problems in connection with this subject. Dimensional change in accurately machined castings—for example, cylinder liners—after having been kept in store, is referred to as ageing, and may in part be associated with internal stresses, and internal stresses have been considered in connection with the failure of chilled rolls. This in any case is one aspect of the matter about which we still know very little.

The Preparation of Cast Iron

I suppose it is still true that the greater part of cast iron used to-day is melted in the cupola. The use of rotary furnaces and electric furnaces is growing, and, of course, some cast iron is still prepared in the crucible furnace.

Even although cupola melting practice is very old there are still many directions in which this practice affects the cast iron that we find difficult to explain. A great deal of interest is being taken by research workers in the effect of cupola melting conditions on the character of the resulting cast iron. It is no secret that the British Cast Iron Research Association have been able to find and trace remarkable effects due to the cupola on the nature and character of the graphite refinement. It is very interesting and very significant that the scientist (if you like to call him this) is at last recognising the importance of cupola melting conditions. This is a vindication of the practical man who has long claimed that he could spoil good iron by bad cupola melting and nobody could tell him why.

In more detail we can consider the question of the character of the coke in its relation to the other aspects of cupola melting and its influence on, for example, the total carbon content. I know of no more difficult practical questions to deal with in connection with cast iron than those connected with carbon pick-up. What are the conditions governing carbon pick-up? A general answer is not difficult, but I think it is always very difficult to deal with an individual case, and I am sure this and related questions can be classed amongst the various things we yet do not know about cast iron.

Moisture in the blast, in the coke, and in the lining materials raises further questions which are not fully understood. These subjects have been discussed previously on many occasions, but we still have a good deal to learn before we fully understand their effects. It is true, of course, that the realisation of the practical importance of some of these and related questions on the part of individual foundrymen depends upon the class of casting he is engaged upon. For

(*Concluded on page* 391.)

Early Development of Ironfounding in England

By RHYS JENKINS, M.I.Mech.E.

This review of the development of the art of ironfounding in England was recently delivered as an address to the Newcomen Society for the Study of the History of Engineering and Technology. It begins with the earliest references, and traces the story down to the middle of the eighteenth century. On a later occasion Mr. Jenkins (who is a Past-President of the Newcomen Society) will complete his survey by extending it to the year 1890.

Introduction

The exhibits of castings of the Bronze Age in the various museums have made everybody familiar with the fact that the art of founding in bronze is of great antiquity. Ironfounding, on the other hand, in Europe, and regarded as a regular trade, is of comparatively modern origin.[1] In this country it followed a great change in the process of smelting. That change was the substitution of the high furnace, known as the blast furnace, for the bloomery, the primitive hearth in which malleable iron such as could be worked by the smith, was produced directly from the ore.

By incorrect working, as by the use of too high a temperature, the primitive hearths or furnaces did, however, sometimes produce fluid cast or pig-iron, and it must have occurred to some of those who saw the molten material that it might be used, as was bronze, to fill moulds. The Greek writer Pausanius, writing about the end of the year 175 A.D. of Theodorus of Samos, who lived some seven hundred years earlier, says that he discovered the melting of iron and the moulding of images from it, and again that to make images of iron is a very difficult task, involving great labour.[2]

An Example from Sussex

Statues and statuettes of cast iron cannot have had the artistic value of those of bronze, probably they were treasured because iron as a cast metal was rare and difficult to work. In various museums throughout the world there are to be seen objects of cast iron which there is good reason for thinking were made from 1,500 to 2,000 years ago. One such object is the statuette now deposited in the Hastings Museum, and something must be said about it, bearing in mind, of course, that the fact that it was found in Sussex does not imply, of necessity, that it was made there.

The cinder deposits of the early iron smelters in Sussex have in the past been largely utilised for road metal. One such deposit, in Beauport Park, on the outskirts of Hastings, was being excavated for this purpose in 1877; that it had been formed in the time of the Roman occupation of Britain was established by the nature of the fragments of pottery and other objects found amongst the cinders. In 1883 a well-known Sussex antiquary, the late Charles Dawson, acquired this statuette from a workman, William Merret, who said he had found it in 1877 while engaged in digging this cinder heap for road metal, and at a depth of 27 ft. from the surface. It is a matter for regret that the circumstances of the find are not better authenticated. The figure, which is 3 in. high, was much corroded when found, but originally it must have been an object of considerable beauty. While there is a general agreement that it is of the Roman period, there has been some diversity of opinion as to whether it is really of cast iron. It may not have the carbon content of good modern foundry iron, but it seems to the author that it was produced by casting in a mould formed on a wax model, that is, by the *cire perdue* process.

Within the last few years another cast-iron figure has been acquired by the Hastings Museum. It is of the same height as the other, and, like it, is said to have been found in Beauport Park, but it is crude both in modelling and workmanship, and must be regarded as modern, that is, as made within the last two hundred years. It was cast in a sand mould and is hollowed at the back.

Early Liquid Metal

In Europe in the middle ages there was an increasing demand for iron, and to meet this it was sought to augment the production of the furnaces, so one finds them being made of increased height and width, producing masses considerably heavier than those produced in the earlier furnaces. These masses, from exposure to great heat while in contact with the charcoal fuel, took up a certain amount of carbon and became in part liquid, so that the product of the furnace, in addition to the spongy mass of malleable iron, consisted also of a proportion of fluid metal which could be tapped off at the bottom of the furnace. This part, cast iron, had now become a sensible part of the product, and the disposal of it a matter for consideration. The knowledge of gunpowder had led to its use in warfare and now bronze cannon were being cast. Bronze was expensive and it was sought to substitute for it the by-product cast iron, probably in the second half of the fourteenth century.

However, at the same time attempts were being made to take out the carbon which the iron had absorbed in the furnace and so to convert it into malleable iron. Success seems to have been attained in these attempts by the end of the century, and it would appear that early in the fifteenth century furnaces were at work from which the iron issued in fluid form only, to be converted into malleable iron by the finery process. Exactly where this change was made is not known, beyond that it was somewhere in Western Germany, Eastern France or Belgium. From, say, 1410 onwards there are authentic records of the production of cannon and cannon-balls of cast iron.

In England there is no evidence of a transition stage, such as the "Stückofen," between the low bloomery hearth and the blast furnace. This furnace, together with the finery process, was brought into this country, probably from Northern France, in the latter half of the fifteenth century.

IRONFOUNDING IN SUSSEX: THE EARLY DAYS

Sussex was the cradle of English ironfounding; it was there that the blast furnace made its first appearance in this country, and there is every reason for thinking that, in England, ironfounding followed the introduction of the blast furnace. The earliest reference is of the year 1490, when a payment of 67s. 2d. was made on behalf of John Morton, the Archbishop of Canterbury, to "ye Ierne founders of Buxstede."[3] There is no information as to the nature of the castings for which this payment was made, but probably they were plates cast in open sand.

Then in 1493 there are accounts of a lawsuit between "Pieter Robert, alias Graunt Pierre, yerne founder, dwelling in Hartfield, and having an iron mill in the Forest of Ashdown," and his former partner Harry Mayer, alias Harry Fyner of Southwark, goldsmith.

In the year 1496, December 13, in preparation for war against the King of Scotland, Henry VII issued a commission to this Harry Fyner to take artificers, "founders" and labourers for building foundries for the making of iron for the ordnance.[4] This is the earliest indication that cannon balls of cast iron were being made or used in this island. Fifteen years before Edward IV had issued a commission to take men, stone cutters, smiths and plumbers for the ordnance,[5] and eight years earlier still the same king appointed John Michell, mason, to take stone cutters and other workmen for the works of stones for cannons for the King's ordnance.[5]

It is clear that Fyner was required to provide cast-iron shot, the date is too early for cast-iron guns, and had the production of malleable iron been in view the commission would have included finers.

In the following year, 1497, not only was "Pieter Robard, *alias* Graunte Pierre" ironfounder of Hartfield engaged in casting pellets at a fee of 6d. a day, but Simon Ballard at Newbridge in Ashdown Forest was casting large balls, some weighing as much as 225 lbs. each in large quantities.[6]

The State Papers record a payment in 1513 to Reignold Robertes for two iron-cast guns weighing together 1,862 lbs.[7] It is possible that this Robertes may have been the son of the Pieter Robert mentioned above and that the guns were cast in this country, but on this point there is no information, in fact, nothing more is recorded of these guns, and in any case it is clear that the cast-iron gun industry did not start until thirty years later.

Ordnance and Fire-Backs

From the beginning the ironfounding industry in Sussex was based mainly on the production of war material, shot and guns, and this was so throughout its whole course. However, before turning to gunfounding, something must be said of the open-sand castings, chimney backs, fire dogs and grave slabs that were produced at the Sussex furnaces as long as they continued at work. Open-sand work is not of particular importance in the history of ironfounding, and the amount of it done was, after all, quite inconsiderable. From the accounts of Worth furnace, it is learnt that for the years 1547-48 the total output of guns, shot and sow iron was 264 tons, and in these two years four chimney backs were made, and they were valued at 3s. 4d. each. Still many of these castings are yet in existence and form the earliest evidence of the work of the English ironfounder. Examples of chimney backs and fire dogs are to be seen in the various museums, such as South Kensington, Lewes, Brighton and Hastings, and they are much sought for by collectors, so much so that there is no doubt that "fakes" have been put on the market.

The chimney backs, also known as fire-backs, are plates intended to protect the wall at the back of an open fire-place on which wood was burned. The earliest documentary reference to their production is that in the Worth furnace accounts, 1547-48, just referred to, but no doubt they were being made long before that, perhaps as early as the last decade of the fifteenth century, or from the time the blast furnace was introduced. At first, one imagines, they would be quite plain plates; a man would bring a piece of board of the size he wanted his plate, to the furnace, and this would be impressed on the sand to make the mould. Next it would occur to the furnaceman, the founder, that some ornament in relief could be made, and he would press into the sand any small objects that came handy; he might get a bit of moulding in wood, or a piece of rope and use that as a repeat. Then, when nobles and men of wealth took to having chimney backs cast, they would employ a craftsman to make a pattern in wood with their arms or other

designs carved therein. There are some fine examples of such backs in existence.

Perhaps the most interesting, seeing that it has some technical value, is that of Richard Lennarde, of Brede furnace. Fire dogs, andirons or brand irons, are to be seen in museums. They consist of a cast-iron upright, standing on two feet and ornamented on the face, with, projecting at the back, a horizontal bar the free end of which is turned down to form a third support. The bar is of wrought iron and the upright was cast upon it. These dogs were placed one on each side of the fire-place to support the ends of the logs being burned. Examples of fire dogs in existence are said to have been made in 1575.

Grave Slabs

The grave slabs are to be seen in many of the churches and churchyards in the county and the adjoining parts of Kent and Surrey. Wadhurst, it appears, has as many as seventeen. An interesting example is the slab of Anne Forster, dated 1591, at Crowhurst, in Surrey. However, since it has been claimed that it is the most ancient piece of cast iron in England, a slab in Burwash Church is that which calls for consideration here. This slab, which measures 5 ft. 6 in. by 18 in. and weighs perhaps 4 cwts., bears in relief and below a cross the inscription:

"Orate P. Annema. Jhone Colins"
(Pray for the soul of Jhone Colins)

The style of lettering has led antiquaries to date the slab as of the fourteenth century. The idea of connecting the form of the letters with the current script must strike anyone acquainted with ironfounding as fanciful. The letters are simple to form and clear. There is no possibility of misreading the words.

More probably it belongs to the sixteenth century, perhaps to the time of Queen Mary, 1553-1558. Probably it is right to assume that "Jhone" is a mis-spelling of "Joan" and not of "John," but research has failed to identify this particular Joan Collins. She may have been the daughter of John Colyn, the elder of Burwash who died in 1541 leaving to his sons John, Alexander and Bartholomew, Burwash forge and Socknersh furnace. Alexander died in 1552, Bartholomew in 1554, but John lived to a great age. The slab was no doubt cast at Socknersh furnace which stood at about two miles from Burwash Church.

Besides the chimney backs, grave slabs, etc., materials were cast for the forges, hammer heads and anvils, and at the end of the century there is clear evidence that the hammer hursts also were being made in cast iron.[8] This is perhaps the earliest example of the use of cast iron in machine construction.

Cast Hardware

No doubt some amount of pot founding in loam was done, at any rate there are, in 1613 and 1617, the names of Anthony and Humfrey Durrant, who are styled pot founders. It is stated, too, that "Many of the culinary articles, called skillets, were also manufactured between the years 1625 and 1670. Some of them bear the name of Rummins. Tradition states that a family of this name, natives of Lamberhurst, travelled about the country with these articles, which they cast at the various foundries of the district, as occasion required."[9]

CAST-IRON GUNS, 1543-1603

King Henry VIII came to the throne in 1509. He at once set about the provision of munitions of war, armour, guns, etc. Built-up iron guns were made in this country and bronze guns were cast for him in Belgium. Then he brought in Italian, French and Flemish founders and had the bronze guns cast in England,[10] but even then he was dependent upon foreign sources for the copper, which formed the main constituent of the bronze. It cannot then be a matter of surprise that, as time went on and the blast furnaces increased in number, consideration should be given to the question whether guns like the bronze guns could not be made of cast iron, a native material much cheaper than bronze.

The story one usually meets is that the first cast-iron guns were made at Buxted in 1543 by Ralph Hogge and Peter Baude. Clearly this is based on Holinshed's "Chronicles," in which we read under the date 1543: "This yeare the first cast pieces of iron that ever were made in England were made at Buckstede in Sussex by Rafe Hoge and Peter Baude."

Stow in "The Annales" gives a somewhat different story and dates the event four years later: "After the King's [Henry VIII] return from Bullen the sayd Peter Bawd by himselfe, in the first of Edward the Sixt [1547] did also make certaine ordinance of cast yron, of divers sorts and forms, as Fawconet, Fawkons, Minnions, Sakers, and other pieces." He goes on to say that John Johnson the "Covenant Servant" of Baude, after his death, "did likewise make and cast yron ordinance, cleaner and to better perfection, to the great use of this land: his sonne, Tho. Johnson is yet living a special workeman, in the yeare 1595 he made 42 pieces of great ordinance of yron for the earle of Cumberland, Demy Canons weying 6,000 lbs. or 3 tunne the piece."

Another account occurs in the distich put on record by Lower ("Contributions to Literature," 1854):

Master Hugget and his man John
They did cast the first can-non.

As to the date it must be remembered that the chroniclers had to rely upon hearsay, and unfortunately the state records in Letters and Papers of Henry VIII supply no information to check it, in fact no mention is made of this event, but, as will appear later, one does learn of cast-iron guns being made for the state in 1545 and 1546 before the death of Henry VIII. Moreover, Peter Baude died before that King, so clearly Stow is wrong in giving the first year Edward VI (1547) as the date. Holinshed is likely to be correct on this point. Stow's account was written nearly fifty years after the event, as appears from the facts that he mentions the date 1595, the Thomas Johnson whom he refers to as yet living died before the middle of 1596.

Stow seems to have received his information directly or indirectly from Thomas Johnson, the son of the "Covenant Servant" of Peter Baude, and he would be unlikely to give much credit to Hogge, who, in his view, merely provided the molten iron. Possibly John Johnson was "his man John" in the old saying quoted above.

As to the name Hugget there is some doubt, it may be a local pronunciation of the name Hogge, how Hogge himself pronounced it we do not know. On the other hand, while the name does not appear in any list of furnace owners, there is a place called Hugget's Furnace, but this is in the parish of Mayfield, not Buxted. Both names, Hogge and Hugget, appear in the current Sussex Directory.

Parson Levet

One may take it then, that in the year 1543 Peter Baude[11] came to Buxted, and at the furnace worked by Ralph Hogge made the mould in which was run the first cast-iron gun made in England. However, it does seem that Hogge has achieved greater renown than he is entitled to. The credit of initiating the founding of cast-iron guns in this country really belongs to William Levet, the parson of Buxted. From 1540 onwards there are records of payments to him for iron shot, and in 1541 he was appointed the King's gunstone maker at a fee of 6d. a day. The furnace at Buxted belonged to him and Hogge was his founder.

Cast-iron guns of some sort had been made long before this in Germany, and, as has been shown, as far back as 1513 Reignold Robertes had supplied the King with "two iron-cast guns," of which nothing further is known. Whether at this time the idea of trying cast-iron in place of bronze came from the King, from the Master of the Ordnance, or from Levet himself, there is nothing to show, but at any rate Levet's official position as iron gunstone maker would point him out as the man to carry the idea into practice, and to arrange that Baude, the King's Gunfounder, a man with a full knowledge of the proportions of bronze guns and the preparation of the moulds for casting them, should travel down to Sussex to prepare the moulds at the furnace.

How it came about that Parson Levet was in the iron trade is an interesting question. Possibly his father may have been in it before him and he may have grown up in an atmosphere of ironmaking. What is known is that his brother, John Levet of Little Horsted, was an ironmaster and that when he died in 1535 the parson acted as executor under his will. John Levet left a son and the parson as his trustee during a long minority would be compelled to take an interest in the ironworks, perhaps to undertake the management. That he had an aptitude for business is suggested by the number of cases in which he is found acting as executor or overseer under the wills of his friends and acquaintances. However this may be, that he soon attained a position of some importance in the iron trade is shown by the fact of his being appointed gunstone maker to the King in 1541, and that it was at his furnace that the gun of 1543 was cast.[12]

Contemporaneous Production of Iron and Bronze Guns

There is no information in regard to the trials of this first gun. No doubt the gunners would prefer to have the bronze guns that they had been accustomed to, and it is clear that Henry VIII did not anticipate that the iron guns would oust the bronze, for in 1546 he was still buying, in one lot, nearly 400 tons of copper from the Fuggers, the great merchants of Augsburg, and this after having a few months earlier bought a lot of 45 tons.

However, it is clear that the guns were found to answer, for some purposes at least, and they were very much cheaper than the bronze. One writer of the period put the cost of the bronze guns at twelve times that of the cast iron, that is, weight for weight.

So the production went on, and for the final years of Henry's reign, 1545 and 1546, the official records show a number of payments to Levet for cast-iron guns. For instance, in May, 1546, a warrant was made out "to pay Parson Levet 300*l* for making iron pieces." This represents about 30 tons and perhaps sixty guns.

The blast furnaces of these days were quite small; when a furnace was first put in blast, the hearth was of such a size that a cast of 6 or 7 cwts. could be made. In course of working, the hearth became enlarged through the wearing away of the stones which formed its sides until, when the furnace went out of blast at the end of the season, a cast of nearly a ton could be run.

Probably the largest guns cast at Buxted were Sakers weighing about 12 cwts., so when, at the end of 1546, Levet was appointed to oversee the ironworks in Worth Forest, it is likely that he at once set about the erection of the double furnace that appears in an inventory made in January, 1549. This furnace could cast culverins weighing, say, 2 tons, for, according to the inventory just mentioned, the stock included 14 culverins and 15 demi-culverins. The accounts of this furnace for the period December 24, 1546, to January 17, 1549, have been printed,[13] and they show that 56 tons of guns and 52 tons of shot were made; the guns are priced at 10*l* a ton and the shot at 4*l*, and it may be assumed that these were cast in the years 1547 and 1548. Apart from this, very little has been discovered about the trade.

However, although little is known about the trade for some years, evidently it was going on in a quiet way, for in 1557, the time of Philip and Mary, there was an Italian visitor commenting upon the number of guns to be seen

at the Tower and on the Tower wharf, and remarking that some of them were of iron, cast in the same way as the bronze guns.[14]

Export of Guns

After Elizabeth came to the throne events moved more quickly and the export trade commenced. By 1568 it had become of some importance, for in that year, twenty-five years after he had cast his first gun, Ralph Hogge was petitioning for and obtaining a grant of the monopoly of the export trade. Six years later he was complaining that his monopoly was being infringed. By this time the number of blast furnaces had increased considerably, there being over forty in the Sussex area. There was a large foreign demand for cast-iron guns; this trade was a lucrative one, and the owners of blast furnaces found it more profitable to cast their product into guns than to supply it to the forges for conversion into wrought iron. The growth of the iron trade created an increased demand for charcoal, a fuel then in common use for domestic and other purposes, and the price of firewood and charcoal went up. Complaints of the destruction of the woodlands followed.

The increasing exportation of guns and shot was also a matter of alarm, since there was little doubt that material from the English foundries found its way into the hands of our enemies or of those who might become enemies. There followed discussions in the Privy Council, Bills and discussions in the House of Commons, proclamations and orders of the Council directed to the restriction of the consumption of wood, and the limitation of the export trade in ordnance. Lists were made of all the furnaces, and the ironmasters were compelled to enter into bonds not to cast guns without licence from the Queen.

There was at the time one furnace outside the Sussex area at which guns were cast. It was that of Edmund Matthews, of Pentyrch, near Cardiff. Hogge in 1574 had mentioned this furnace, and Matthews, like the other ironmasters, had had to enter into bonds not to cast guns. However, he continued to do so, and in 1602 the Privy Council issued an order that "Edmund Matthews to be put down for casting ordnance at his furnace near Cardiff whence it may easily be carried into Spain, for five or six years last past, most that he has made has been stolen beyond the seas, and as the officers at that port are poor, and dare not displease him, that place is very unfit for casting ordnance." Matthews now gave up gunfounding on his own account and let his furnace to Peter Samyne, who no doubt went into the trade with vigour. It would take some time for the news that he was doing so to reach London, and still more before any effective action could be taken against him.

Although it was found that there was a statute in force (28 Edward VI, *c.* 5) by which the exportation of iron was prohibited, licences to export cast-iron guns and shot seem to have been obtained without much difficulty. When they could not be got the ironmasters found means of evading their obligations.

There is a long list of export warrants for the reign of Elizabeth; all through a good many guns were sent to the Low Countries, some went to France, and Portugal in the year 1582 took 132 pieces. Other purchasers were the Duke of Brunswick, the Duke of Pomerania, the Duke of Stettin, and the Count of Friesland.

The records available do not enable the giving of the number and weight of guns, the exportation of which was authorised, and of the guns smuggled out of the country naturally there is no official record. It is clear that a good deal of unauthorised exportation went on. Some idea of the make may be gathered from the following:—

Thomas Johnson, Her Majesty's Gunfounder in 1593, said that in the eight years preceding he had cast 345 pieces. In 1609 Thomas Hodgson, of Pownsley, in Sussex, stated that he had sold 516 tons, but he does not say in how many years. Barnabe Hodgson, of Mayfield, said that he had sold 231 pieces in the ten years last past. Thomas Browne, of Ashurst, in Kent, stated that he had delivered to various persons 463 tons of iron ordnance since 1591, *i.e.*, in eighteen years. Peter Samyne, of Cardiff, has had his furnace about nine years, but cannot say how much iron ordnance has been made. Edmund Matthews said that before he let his furnace to Samyne, he had made about 150 tons. In 1601 it was stated that the annual make for the past few years was 800 tons. This figure is probably near the mark.

These figures, striking enough at the time, appear insignificant to-day. It is to be remembered that the furnaces were small, used charcoal as fuel, and were blown by bellows worked by water wheels.

The explanation for the large and continuous foreign demand for the English cast-iron guns is not easy to give. In the reign of James I (in 1623) it was stated that "the English ordnance is growne to that usefull serviceableness which now it hath as well by the perfecting of time and the skill of the workmen as by the qualitie of the mettall." The Sussex men seem to have taken readily to, and to have become expert in, loam moulding, and no doubt the iron was a good strong foundry iron, but Sussex had no monopoly in that.

In so far as concerns the reign of Elizabeth, another question presents itself, that is—were cast-iron guns being made on the Continent? It has been shown that in earlier times ordnance of cast iron was being made in Germany, and no doubt such was the case in Italy and France also. These pieces were of the mortar type, large in diameter and of short length. The culverins, sakers, etc., now being exported were of entirely different proportions, of small calibre and great length, and it seems likely that their production in cast iron had not been embarked upon on the Continent. This view seems to be confirmed by the letter of an Englishman writing home from Spain in 1598, who said: "Ships from Spain going to the Indies and Brazil carry cast pieces of iron and all seafaring men agree that they never see cast ordance of iron but such as be made in England." This writer refers to a licence granted to Lord Buckhurst to export 1,000 tons of cast-iron ordnance to Flanders, France and Scotland; he thinks it should be called in "as the ordnance is retransported into Spain and Portugal, and used against us."

(To be concluded.)

REFERENCES.

1 It seems to be well established that in China the trade of iron-founding was being carried on some centuries earlier than in Europe.

2 Pausanius, "Description of Greece" (Loeb edition), Book III, XII, 10. "Leading from the market place is another road, in which they have built what is called Scias (Canopy) where even at the present day they hold their meetings of the Assembly. This Canopy was made, they say, by Theodorus of Samos, who discovered the melting of iron and the moulding of images from it."

3 Lambeth Library, Roll No. 1352 (Receiver's Accounts).

4 Col. Pat. Rolls, 12 Hen. VII.

5 Col. Pat. Rolls, Edw. IV.

6 L. F. Salzman, "English Industries in the Middle Ages," 1923, p. 163, quoting Exch. Tr. of R. Misc. Bks, 8, f. 139.

7 Letters and Papers, Hen. VIII, Vol. I, pt. ii, p. 1511.

8 Hist. MSS. Com. The manuscripts of the Duke of Rutland at Belvoir Castle, IV, 445.

9 "Iron Works of the County of Sussex": Lower, Sussex Archl. Colls., 11, 196.

10 For an interesting account of this period, particularly of the bronze guns and the founders, see: Charles ffoulkes, "The Gun Founders of England," 1937. The production of cast-iron guns in Sussex is dealt with by Ernest Straker, "Wealden Iron."

11 Peter Bawood, from France, "maker of our bombards," was naturalised in 1542 by Letters Patent of Henry VIII. He died before 25 March, 1545, from which date John and Thomas Owen succeeded him in the office of King's Gunfounder.

12 William Levet became Rector of Buxted in 1533, two years before the death of his brother and ten years before the casting of the gun mentioned. He died in 1554, perhaps thirty years before Holinshed was writing and, no doubt, by that time his name had passed into oblivion.

13 Guiseppi MS., The Accounts of the Ironworks at Sheffield and Worth in Sussex, 1545–1549. "The Archæological Journal," 25, Vol. XIX, pp. 276–311. The Worth ironworks had belonged to the Duke of Norfolk; upon his attainder in 1546 his possessions came into the hands of the King. In 1547, the works was leased to Sir Thomas Seymore, who, in turn, was attainted in 1549. It was on this occasion that the inventory referred to was made (the inventory will be found in print in "Sussex Arch. Coll."). Later, the works was leased to Clement Throck-Morton, but on the accession of Queen Mary (1553) was restored to the Duke of Norfolk.

14 Calendar of State Papers, Venice. Annibale Litolfi to Guglielmo Gonzaga, Duke of Mantua, from London, June 20, 1557.

What We Do Not Know About Cast Iron

(*Concluded from page* 388.)

example, one of my friends who is engaged upon the production of individually-cast piston rings recognises the effect of moisture in the blast. It is his practice to record systematically the barometric and humidity conditions and in fact has equipped his cupolas with dry blast installation. He is able to show the effect of this in reducing his scrap figures arising principally from hardness, but he is yet unable to explain exactly why.

Another aspect of the preparation of cast iron is the nature of the mixture. I could, of course, recite endless cases in support of the well-known view of foundrymen that different pig-irons vary in properties in a manner not yet thoroughly understood. I think these matters have been discussed sufficiently well for you to agree that they contain a quantity of the "things we do not know about." One aspect of this question of metal mixtures which is not discussed quite so often is the effect of the nature and percentage of scrap. Again, the recognition of the possibility of deleterious effects depends upon the nature of the products, and those foundrymen who are dealing with castings which are machined all over and which have to be free from the slightest blemish are more likely to recognise the importance of this. The importance of this question has arisen also in connection with some of the alloy cast irons. Cases can be cited where, when a certain percentage of returned scrap is exceeded, trouble due to unsoundness is experienced, and it has not been found possible always to provide a complete explanation.

Soundness

This perhaps leads me to the question of soundness and shrinkage problems. I think you all know that a considerable amount of attention on the part of systematic research is being devoted to this question. It is true to say that a good deal of progress has been made particularly in the direction of the influence of composition on unsoundness and shrinkage. There is still a lot we do not know, and I can imagine anyone cynically inclined saying that the most important thing we do not know about cast iron is how to produce sound castings.

Catalogue Received

Moulding Machines. The Adaptable Moulding Machine Company, Limited, of Sydney Works, Stanhope Street, Birmingham, 12, have prepared an essentially businesslike catalogue dealing with the Nicholls moulding machine. It is characteristic of this machine that the jolting and squeezing cylinders and the pattern stripping guides are all incorporated in a one-piece base casting. This obviously eliminates the combination of screwed-up parts, which tend to work loose and may interrupt production. No less than ten types are illustrated, and beneath the illustrations are blue prints detailing the overall dimensions. Under the blue print is tabulated the main features of the specifications, such as working pressure; air consumption per cycle, size of moulding box used, the lift, size and weight figures, and major dimensions.

The lubrication, a very important factor in moulding machine operation, is automatically effected by the air supply. The lowering of the pattern-plate table together with the moulding plate and pattern requires no air consumption, which source of power is confined to the jolting and squeezing operations. The pamphlet is available to our readers on request to the Birmingham works.

Electric Furnaces in European Steelworks

By DONALD F. CAMPBELL

(*Concluded from page* 365.)

The designer of high-frequency furnaces has to compromise between the requirements of the metallurgist and the electrical engineer, and the problems involved are most interesting. The principal variables for a given size of furnace are the periodicity, power, voltage, and cost. The movement of the metal depends on the first two, the difficulties of construction and cost of equipment depending largely on the voltage and periodicity used.

Three methods of construction of these furnaces are in common use, each designed to avoid excessive heating of the outer furnace shell or frame by induced currents:—(*a*) The smaller furnace bodies made of non-magnetic metal frames, carefully insulated at the corners to avoid complete secondary circuits with panels of asbestos-cement, as in Fig. 4. (*b*) Steel furnace bodies, in which there is a laminated iron shield between the inductor coil and steel structure. This construction gives a compact and strong furnace body, but one which may be rather expensive to repair if there is a breakout of steel. Such a

FIG. 4.—SMALL HIGH-FREQUENCY INSTALLATION.

furnace is shown in Fig. 5. (*c*) A steel furnace body protected from induced currents by a copper shield (*see* Fig. 6). This involves a much larger spacing between coil and furnace body and greater difficulty in designing a strong support for the coils. The furnace is larger and the spout longer, but the damage done by metal breaking through is slightly less than with the construction described in (*b*) above.

The electrical characteristics of European furnaces vary slightly in different countries. In one installation on the Continent, the generators have a maximum rating of 1,650 kw. at 3,000 volts, 600 cycles, and are connected to four furnaces, one of 8 tons, one of 6 tons and two of smaller capacity. The normal melting time of the 6-ton furnace is just over 3½ hrs., and the energy consumption is about 670 kw.-hrs. per ton. This is the average of many heats, most of which were alloy steels. This 8-ton furnace has a normal melting time of 4½ hrs., and the energy consumption is about 680 kw.-hrs. per ton.

Another large Continental equipment comprises a 4-ton and a 7½-ton furnace connected to a 1,400-kw., 600-cycle alternator. The larger furnace is intended to deal with molten-metal charges.

In these furnaces, the furnace is lined with copper and is supported in a skeleton framework of steel. The shell has a considerably larger diameter than the inductor coil, and, in fact, there is sufficient room between the coil and the body for a man to climb down to repair the coil. This reduces the time for which the furnace would be out of service in the event of a breakdown, but has the disadvantage that it is more difficult to give rigid support to the coil. The inductor coils in these furnaces have in general a single conductor of hollow, square-section copper. The wall thickness is from 4 to 6 mm.

In England two large equipments of 1,500-kw. and 1,250-kw. rating respectively may be described as typical of present British practice. One installation consists of two independent generators built in a single stator, each of 625 kw., 1,125 cycles, 1,500 volts, driven by a 6,600-volt, 1,500-r.p.m. synchronous motor. By means of the switch gear installed, either two independent 1,500-volt, 625-kw. supplies or one 3,000-volt, 1,250-kw. supply can be obtained. The condensers are arranged in the form of a three-wire system to enable this to be done conveniently.

There are now three furnaces, two of 5 tons and one of 2 tons capacity. The 2-ton furnace is rated at 625 kw., 1,500 volts. Working on alloy steels, the average melting time is 1¾ to 2 hrs., and the energy consumption 580 to 600 kw.-hrs. per ton.

The two 5-ton furnaces are connected with one another by means of a change-over switch and are frequently used for duplexing with an open-hearth furnace, the power rating under these conditions being 625 kw. For melting cold charges, the melting times are 5½ to 6 hrs. on 625 kw., or about 3½ hrs. on 1,250 kw.

Another installation consists of a 1,500-kw., 2,700-volt, 1,000-cycle generator connected to two 5-ton furnaces through a change-over switch.

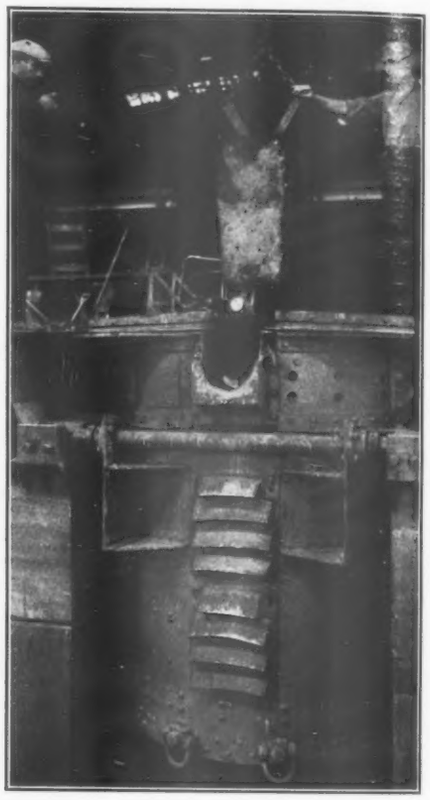

FIG. 5.—LARGE HIGH-FREQUENCY FURNACE WITH IRON SHIELD.

Only one furnace is operated at a time. These furnaces are chiefly used for stainless steels, and are lined either acid or basic. The total melting time is from 3 to 4 hrs., including a long quality refining period. The average energy consumption is about 600 kw.-hrs. per ton, or somewhat higher for some special steels. All these furnaces are of the steel-body, magnetically-screened type, and are very compact and efficient.

The following record indicates a typical heat with a British iron-shielded 5-ton furnace making an austenitic-stainless steel:—Generator output, 1,500 kw., 2,700-volt normal rating; weight of charge, 12,880 lbs.; energy to melt, 3,206 kw.-hrs.; energy from melt to pour, 384 kw.-hrs.; total energy, 3,590 kw.-hrs.; energy per ton (2,240 lbs.), 625 kw.-hrs.

Time.	Volts.	kw. (H.F.).
7.42	2,450	1,400
8.08	2,890	700
8.33	2,700	800
9.15	2,700	850
10.05	2,700	1,100
10.53	2,700	1,300
11.05	1,400	265
11.24	Off to tap	

There are many smaller furnaces of 300 to 1,000 lbs. capacity, rated at 150 or 200 kw., constructed of non-magnetic materials with insulated

joints in the framework when necessary to prevent circulating currents. The normal voltage for these is 1,200 volts, and the frequency 2,250 cycles. The energy consumption is about 650 to 700 kw.-hrs. per ton. The inductor coils, in general, for all sizes of furnaces in England, have a thicker wall of copper on the side nearest the metal, this being obtained either by soldering an additional strip on to a copper tube or by a special extruded section. The purpose of this is to give added security in the event of a lining failure allowing molten metal to come into contact with the coil. With a plain tubular coil explosions have occurred, due to the molten steel coming into contact with the cooling water, owing to short circuits or molten metal breaking through the linings.

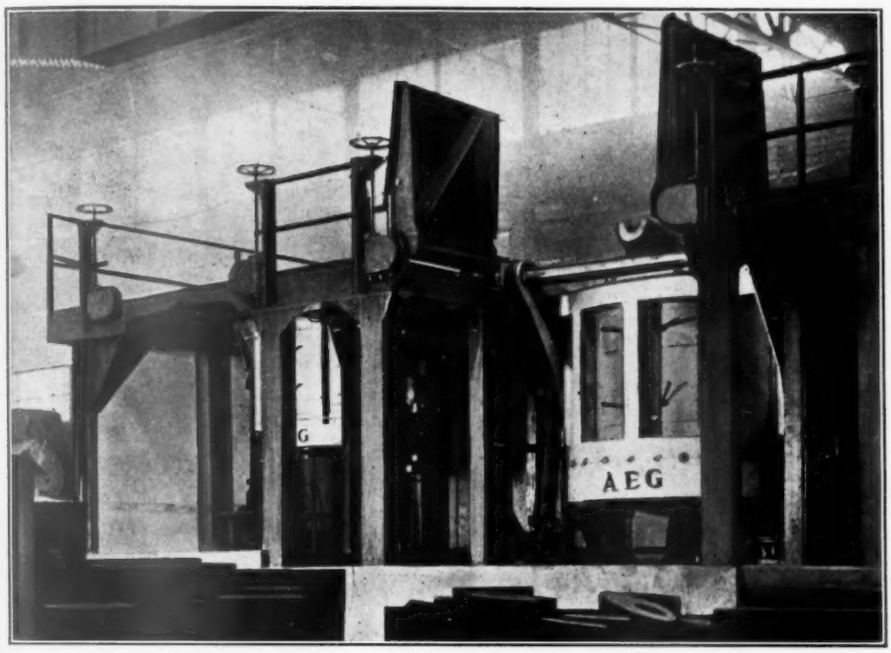

Fig. 6.—High-Frequency Furnace with Copper Shield.

Many coils of complicated structure have been constructed to give higher electrical efficiency, but these have usually been abandoned in favour of a simpler section which is required to withstand the rough usage inevitable when breaking out used linings.

The question of safety in high-frequency induction furnaces has been given much anxious study, as a water-cooled copper coil operating at 3,000 volts within 3 or 4 in. of 6 or 8 tons of molten steel presents a formidable problem.

Although surprisingly little trouble has occurred, precautions are constantly being taken to reduce the risk and to enable still larger furnaces to be built. In the case of a 1,600-kw. furnace, the coil carries approximately 16,000 k.v.a. at 3,000 volts, and to maintain proper insulation humidity must be avoided, and precautions are now taken to indicate the approach of any liquid metal to the coil.

A further recent development in England is the installation of protective apparatus to give warning of contact between the charge and the inductor coil in the event of a lining failure. This comprises a device for electrically connecting the charge to earth and a relay system connected to the inductor coil, which cuts off the current and lights a warning lamp when the charge makes contact with any part of the coil.

This earthing of the charge has the additional advantage that it reduces the liability of the melter getting an electric shock from the charge. This is important with the large equipments where the voltage is 2,500 to 3,000 volts, and parasitic voltages on the charge might otherwise exist to the danger of the furnace operator. On the question of the risk of electric shock, it is interesting to compare the practice in Great Britain and on the Continent. The standard British practice is to have a furnace top of insulating material, either firebrick or asbestos-cement board, and a working platform covered in timber. Moreover, all exposed steelwork in the near vicinity of the furnace is similarly covered. On the Continent no such precautions are taken, and one frequently encounters working platforms and furnace tops of bare steel. Wooden pokers and sometimes wooden shoes are relied on to give some protection.

With regard to generating equipment, the homopolar type of generator is now almost exclusively used in Great Britain and France, although some of the recent Continental equipments have used the wound-rotor type where comparatively low frequencies (*e.g.*, 600) are used.

Particularly on the higher frequencies, the homopolar design is much superior, being much more robust. As has been proved by experience, the liability to breakdown is much less with the homopolar than with the wound-rotor design, as there are no windings on the rotor and no wedges or insulating material that can easily loosen under mechanical vibration.

Modern European equipments nearly always use naturally-cooled condensers, although in some cases a cooling fan is installed. Whereas a few years ago condenser failures were common, condensers can now be relied upon to give good service.

Control gear has advanced considerably, automatic control of the power and power factor being now often installed, particularly the latter. This enables the furnace operator to devote more of his time to the metallurgical control of the furnace. With an up-to-date installation, the furnace operator need visit the control panel only to switch the furnace on or off, or to alter the power.

The arrangement of high-frequency furnaces in melting shops is shown in Figs. 7, 8 and 9.

In all these cases, the shops have been designed for this type of furnace, and the equipment has not been installed in a corner of a steelworks, which, unfortunately, is so often the fate of new types of equipment.

The first illustration (Fig. 7) shows a light shop engaged in the manufacture of high-grade steels in furnaces of 200 to 3,000 lbs. capacity. The smallest is used for experimental heats and small orders for impatient customers, and the others for the production of 40 to 50 qualities of special steels. Two motor-generator sets are installed about a hundred yards from the melting shop in a clean well-ventilated substation, the transmission of high-frequency current presenting no difficulties with proper cable and cable-duct design. The smaller furnaces are of simple design without magnetic shields, the larger being provided with laminated-iron magnetic shields. The melting shop consists of two bays, one equipped with rail and road track, an overhead crane, and a large number of fixed and portable steel bunkers for the classification of various qualities of alloy-steel scrap and its storage in a dry building. Great importance is attached to the careful storage and classification of scrap, as great waste in this respect occurs in many badly-managed works.

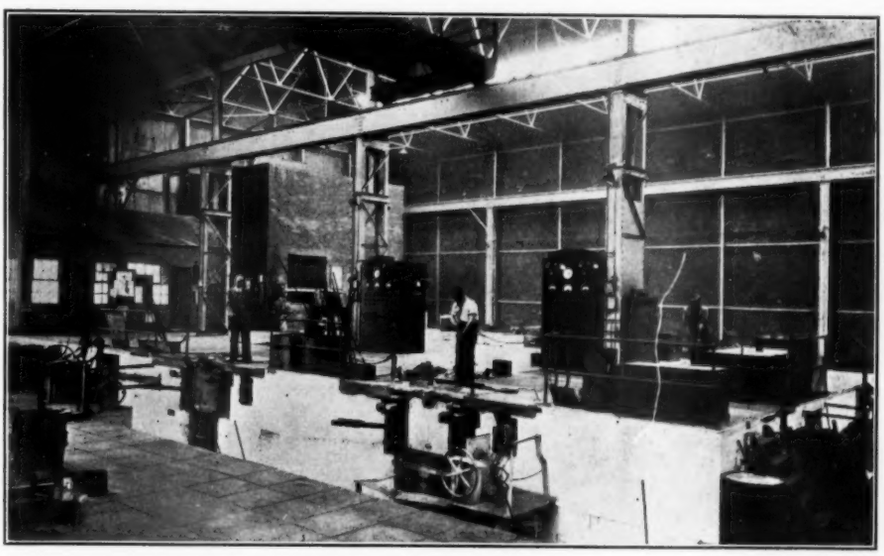

Fig. 7.—British High-Frequency Furnace Shop for Tool Steels.

The furnace tops are all flush with the platform, and this illustration shows the standard British practice of building high-frequency fur-

naces with insulated platforms, and no metallic part of the furnaces, connected to earth, is exposed.

Fig. 8 shows a British shop equipped with larger furnaces, all of which are built with laminated iron shields. Here, again, the furnace tops are at platform level, and hydraulic tilting is used and designed to give a great range of tilting speed, forwards and backwards, for special metallurgical operations and casting, either direct into ingot moulds or into a ladle. In this shop, a considerable tonnage of steel is made by the duplex process, basic open-hearth steel being very rapidly melted in a tilting furnace and transferred to the electric furnace for quality refining.

FIG. 8.—BRITISH HIGH-FREQUENCY MELTING SHOP FOR LARGE OUTPUT AND DUPLEX WORKING.

At this works, two motor-generator sets, having an output of 1,250 kw., are installed in a separate power station, the energy being transmitted to the control panel on the furnace platform and to the condensers in a cellar below. Casting may be done direct into moulds on a carriage equipped with longitudinal and transverse mechanically-controlled movements, or by the use of a ladle. A well-equipped shop for the storage, classification and weighing of scrap is adjacent to the melting shop, and all operations are carried out with scrupulous care and cleanness, the dust and dirt usually found in melting shops being conspicuous by their absence.

Fig. 9 illustrates a recent installation of furnaces of German design rated at 6 and 8 tons with two smaller bodies of 1,700 and 330 lbs., respectively, in an Italian works. The furnaces are built slightly above the platform level, and a good deal of ironwork is exposed. The platform arrangements differ considerably from British practice, a removable platform being provided in front of the furnace, instead of placing the furnace spouts on the edge of the working platform over a casting pit, as shown in Fig. 8.

In Europe it is generally considered that the furnace operator should be able to stand above his furnace, whether he steps up a few inches on to the furnace itself, as in Fig. 9, or stands on the working platform level, round the furnace, as in Fig. 8. The placing of furnaces a considerable height above the platform level, as sometimes practised in the United States, has found no favour in Europe. The larger British furnaces being built with laminated iron shields are smaller than those with copper shields, and consequently the furnace top at platform level is more convenient than the German method of raising the furnace, which is more suitable to furnaces which are large enough to have a top plate of sufficient width for the furnacemen to stand on.

FIG. 9.—LARGE HIGH-FREQUENCY SHOP OF CONTINENTAL DESIGN.

It is interesting to note that there is comparatively little difference in the power consumption between large and small furnaces, the usual figures varying from 600 to 800 kw.-hrs. per ton, according to the quality of steel manufactured or the metallurgical operation performed.

The efficiency of modern high-frequency machines, especially of the homopolar type, is now so high and the electric furnace losses are so low that there is little hope of substantial improvement, and it is in the metallurgical field that there is much development work to be done. Considerable effort has been made in Europe to construct induction furnaces having violent and controlled movement in the bath. Large sums of money have been spent, but in many cases without a full understanding of the metallurgical problems, and, as a result, furnaces showing most interesting electrical phenomena have been built, and abandoned because no metallurgical advantages were established.

Electrical forces can give heat and movement in a great variety of combinations, and a nice balance between these phenomena is necessary to get metallurgical results within the limits set by the lack of data on refractories.

This field of investigation of simultaneous motion and heat control is full of possibilities, and the new knowledge of rapid metallurgical reaction by the mechanical mixing of slag and steel, without prejudice to the inclusion characteristics of the metal, points to great possibilities of furnaces operating in high- or low- or dual-frequency electrical fields.

Notes from the U.S.A.

After four years of extensive research, the Monarch Machine Tool Company, of Sidney, Ohio, has announced a process which facilitates heat-treatment of the ways of large lathe beds without the necessity of building a furnace sufficiently large to accommodate the entire casting. No furnace at all is required under the new method. Heating and quenching operations are carried out simultaneously through use of a specially designed oxy-acetylene torch equipped with a series of water jets for quenching, which follow immediately behind the burner tip.

In this new flame-hardening process the lathe bed is immersed in a tank of water to a point just below the ways, and a motor-driven mechanism then draws the heating and quenching unit at uniform speed over the ways. Only one pass over the bed is necessary. Travel rate of burner tips over bed ways depends on bed thickness, varying from 3 to 6 in. per minute. Test strips, corresponding to different sections of ways, are used to determine the proper burner tips, the amount of heat required and the rate of travel. Depth penetration of the hardened surface can be varied from $\frac{1}{8}$ to $\frac{1}{4}$ in., and Brinell hardness increased from 225 to 240 "as cast" up to 575 to 590 after treatment.

International Nickel Company

A net profit of $7,552,123, equivalent to 48 cents a share on the common stock after allowing for preferred dividend, is reported for the third quarter of 1938 in the quarterly statement of the International Nickel Company of Canada, Limited. This compares with a net profit of $6,618,486 for the previous quarter, and with $13,030,029 for the third quarter of 1937. Net profits for the first nine months of 1938 were $24,284,374, as compared with $38,944,380 for the similar period in 1937, or $1.56 a share, against $2.57 a year ago. The quarterly dividends on the common stock have remained at 50 cents a share.

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The Week's News in Brief

Trade Talk

MESSRS. WILLIAM DOXFORD & SONS, LIMITED, Sunderland, have received an order for a motor vessel of 9,500 tons for Greek interests.

THE FOUNDRY DEPARTMENT of the Staveley Coal & Iron Company, Limited, held their seventh annual social and dance in the Odeon Ballroom, Chesterfield. Over 300 people attended.

PALMERS (HEBBURN) COMPANY, LIMITED, Hebburn-on-Tyne, have received a contract from the Blue Star line for extensive alterations to the liner "Alandora Star" (15,474 tons).

FERGUSON BROS. (PORT GLASGOW), LIMITED, have received an order for a self-propelling bucket hopper dredger from the Scottish Fishery Board. The firm has also booked an order for a light draught passenger and cargo vessel for service in the East.

TO COMPLY with Stock Exchange regulations, particulars have recently been published of Light-alloys, Limited, aluminium alloy founders and engineers. The authorised capital is £150,000 in 5s. shares and the issued capital has recently been increased from £80,000 to £120,000 by the capitalisation of £40,000 from reserves. There are no outstanding mortgages or debentures.

AGREEMENT HAS BEEN REACHED between John Brown & Company, Limited, and Associated Electrical Industries, Limited, under which approximately 70 per cent. of the shares and the control of the Westland Aircraft Company, Limited, has passed to these two concerns. They will rapidly increase the output of the Westland plant, for which large extensions are already in hand.

THE ACCOUNTS of United Engineers, Limited, Singapore, for the year ended June 30 last, after making provision for depreciation, show a net profit of $601,597, which with the balance of $114,719 brought forward, gives a total of $716,317 available for distribution. The directors recommend a dividend of 12½ per cent. on the ordinary shares, amounting to $290,225, carrying forward $164,842.

THE SERIES of Cantor Lectures arranged by the Royal Society of Arts this session will deal with "Refractory Materials." The lecturer is Dr. J. H. Partridge, B.Sc. (of the research staff of the General Electric Company, Limited). The first of the three lectures was presented last Monday. The other two will be delivered at 8 p.m. on November 28 and December 5, at the premises of the Society, John Street, Adelphi, London, W.C.2.

AT THE ANNUAL MEETING of the Meehanite Research Institute, held in Rochester, N.Y., recently, Mr. O. Smalley (President of the Meehanite Metal Corporation, Pittsburgh, Pa.) was re-elected President; Mr. H. B. Hanley (foundry manager of the American Laundry Machinery Company, Rochester, N.Y.), Vice-President; and Mr. F. M. Robbins (President of Ross-Meehan Foundries, Chattanooga, Tenn.), secretary-treasurer. Research and advertising activities are to receive special emphasis under the supervision of Mr. A. C. Denison (President of Fulton Foundry & Machine Company, Cleveland, Ohio) as chairman of Research Committee, and Mr. Peter E. Rentschler (President of Hamilton Foundry & Machine Company, Hamilton, Ohio) as chairman of the Advertising Committee. Some 46 research Papers were presented on a variety of subjects, and over 65 representatives of the Meehanite licensees throughout the U.S.A., Canada, and South Africa attended the meetings and discussions.

THE IMPORT DUTIES ADVISORY COMMITTEE announce that they have under consideration the following applications:—(*a*) For the reduction of duty on consignments of the following iron and steel products, when imported with a quota certificate and certificate of origin under the provisions of Section 6 of the Finance Act, 1936: black or galvanised bolts and nuts exceeding ⅜ in. in maximum thread diameter; screws for wood (other than coach screws, screw hooks, screw rings, screw knobs and tirefonds); nails (including hob nails and boot and shoe studs and spikes), tacks and staples (other than insulated staples); (*b*) for the increase of duty on iron and steel screws for wood (other than coach screws, screw hooks, screw rings, screw knobs and tirefonds), unless imported with a quota certificate and certificate of origin under the provisions of Section 6 of the Finance Act, 1936. Any representations which interested parties may desire to make in regard to these applications should be addressed in writing to the Secretary, Import Duties Advisory Committee, Shell-Mex House, Strand, London, W.C.2, not later than December 9, 1938.

THE EIRE PRICES COMMISSION announces that it has been requested by the Eire Minister for Industry and Commerce to review the operation of the customs duties and the restrictions on the importation into Eire of a number of articles, including iron and steel vitreous-enamelled hollow-ware, enumerated, comprising every article of vitreous-enamelled hollow-ware of wrought iron or wrought steel, or a combination of wrought iron and wrought steel, of any of the following descriptions, which is, in the opinion of the Revenue Commissioners, suitable for domestic or household use, that is to say:—(*a*) Basins, bowls, baths (other than baths which, in the opinion of the Revenue Commissioners, are designed, constructed, and suitable for installation as fixtures in houses or other buildings), buckets, and pails, of which the diameter (measured externally in a horizontal plane at or near the opening in the manner or at the position which gives the greatest measurement) is not less than 10 in.; (*b*) chamber-pots; (*c*) saucepans, stewpans, and cooking pots (excluding tea-pots and coffee-pots); (*d*) jugs and ewers of a capacity of not less than one and one-half pints.

Personal

MR. JAMES MACGOWAN, works manager of Shanks & Company, Limited, of Barrhead, who has retired after 50 years' service, has been presented with a wireless set from his colleagues to mark the occasion.

MR. ARTHUR CHAMBERLAIN, chairman of Tube Investments, Limited, and a director of the General Electric Company, Limited, Stewarts and Lloyds, Limited, and other companies, has been elected a director of the Midland Bank.

MR. ALFRED FAIRCLOUGH has completed 60 years' service with Wilson & Longbottom, Limited, engineers and ironfounders, of Barnsley, and has received presentations from the firm and workpeople. Mr. Fairclough's father, who was works manager, served the firm for 65 years.

Wills

BARFIELD, A. E., chairman of Wild-Barfield Electric Furnaces, Limited ...	£36,758
BUSWELL, EDWIN, chairman and joint managing director of Buswell & Sweeney, Limited, jig, tool and gauge manufacturers, Birmingham	£6,794

Obituary

MR. HARRY HODGSON, principal of the former firm of Scott & Hodgson, engineers, of Guidebridge, Ashton-under-Lyne, died recently. He was 74 years of age.

THE DEATH has occurred in his 92nd year of Mr. Thomas Willett, J.P., Prospect House, Audley, Stoke-on-Trent, who established a business in Liverpool Road, Burslem, known as the Victoria Foundry.

SIR WALTER GEORGE KENT has died at the age of 80. Sir Walter, who was knighted in 1929, was educated at Tunbridge Wells and University College, London. He gained a specialised engineering knowledge in his father's firm of George Kent, Limited, of Luton. For many years he was chairman and managing director, his service and that of his father with the firm going back for 100 years.

MR. WILLIAM A. WARD, assistant managing director of Thos. W. Ward, Limited, Sheffield, and eldest son of the chairman, Mr. Joseph Ward, J.P., died on November 11. He was educated at Leys, Cambridge and Sheffield University, and served his apprenticeship to engineering in West Yorkshire, and the electrical industries in Wolverhampton. Mr. Ward commenced his career with Thos. W. Ward, Limited, over 31 years ago, was appointed a local director in 1919, became a full director in 1925, and in March, 1928, was appointed assistant managing director. He was an engineer of wide experience and was specially connected with the machinery and engineering activities of the company. In this connection he made a number of trips to various European countries and the United States of America.

Contracts Open

Cawnpore, January 2.—Supply and erection of electric pumping machinery, for the Cawnpore Municipal Board. Williams, Temple & Bartholomew, consulting engineers, 28, Victoria Street, Westminster, S.W.1. (Fee £2 2s., returnable.)

Cawnpore, January 2.—Supply and erection of ten installations of automatically-controlled motor-driven pumps, each installation consisting of three motors and pumps for high pressure and one motor and pump for low pressure, together with pneumatic tanks, air compressors, automatic electrical control apparatus, suction and delivery pipes and accessories, for the Cawnpore Municipal Board. Williams, Temple & Bartholomew, consulting engineers, 28, Victoria Street, Westminster, S.W.1. (Fee £2 2s., returnable.)

Cairo, December 15.—Two low-lift centrifugal pumps and two impellers, for the Nile Circle Department of the Egyptian Ministry of Public Works. (D.O.T. reference T. 28,840/38.)

Johannesburg, January 4.—Supply and erection of deep-well pump and motor, etc., for the Rand Water Board. (D.O.T. reference T. 28,772/38.)

Keynsham, December 3.—Ironworks for the period January 1, 1939, to March 31, 1940, for the Urban District Council. The Surveyor, Council Offices, Keynsham.

Company Reports

Irish Aluminium Company, Limited.—Dividend of 5 per cent.

Foster, Yates & Thom, Limited.—Dividend of 6 per cent.

Birmid Industries, Limited.—Dividend of 10 per cent. plus a bonus of 2½ per cent., in respect of the year ended October 31 last.

Walmsleys (Bury), Limited.—Net profit for the year ended September 30, after £30,000 for taxation, £64,989; final dividend of 8 per cent. on the ordinary shares, making 13 per cent. for the year; carried forward, £93,890.

Butler Machine Tool Company, Limited.—Profit for the year ended September 30, after £3,326 for N.D.C., £59,679; brought in, £4,753; income-tax, £3,375; written off goodwill and patents, £5,390; dividend of 15 per cent. and a bonus of 2½ per cent. on the ordinary shares; carried forward, £14,412.

Brown, Bayley's Steel Works, Limited.—Profit for the year to July 30, £154,449; brought in, £28,492; dividend on the cumulative preference shares, £25,000; dividend of 15 per cent., free of tax, on the ordinary shares, £45,000; to general reserve, £50,000; to reserve for obsolescence, £25,000; carried forward, £37,941.

Forthcoming Events

DECEMBER 1.

Institute of Metals (Birmingham Section):—"Light Alloys for Aircraft," Paper by H. Sutton, at James Watt Memorial Institute, Birmingham, at 7 p.m.

DECEMBER 2.

Institution of Mechanical Engineers:—Third Parsons Memorial Lecture: "Sir Charles Parsons and Marine Propulsion," by S. S. Cook, F.R.S., at Storey's Gate, London, S.W.1, at 6 p.m.

Institute of British Foundrymen

DECEMBER 1.

Sheffield Branch:—Report of Cast-Iron Sub-Committee, presented by P. A. Russell, at Royal Victoria Hotel, Sheffield, at 7.30 p.m.

DECEMBER 2.

Birmingham, Coventry and West Midlands Branch:—"Foundry Melting Furnaces," Paper by S. E. Dawson, at James Watt Memorial Institute, Birmingham, at 7.30 p.m.

DECEMBER 3.

Bristol Section:—"Hydraulic Pumps and Rams," Paper by F. G. Jackson, at Merchant Venturers' Technical College, Bristol, at 7 p.m.

Middlesbrough and Newcastle Branches:—Joint meeting. Visits to L.N.E.R. North Road Locomotive Works, and Thos. Summerson & Sons, Limited, Albert Hill Foundry, Darlington.

The Institute of Vitreous Enamellers

DECEMBER 1.

Northern Section:—"Comparison of Vitreous Enamelling in U.S.A. and England, with Reference to the I.V.E. Official Visit to the United States," Paper by A. England, at Queen's Hotel, Piccadilly, Manchester, at 7.30 p.m.

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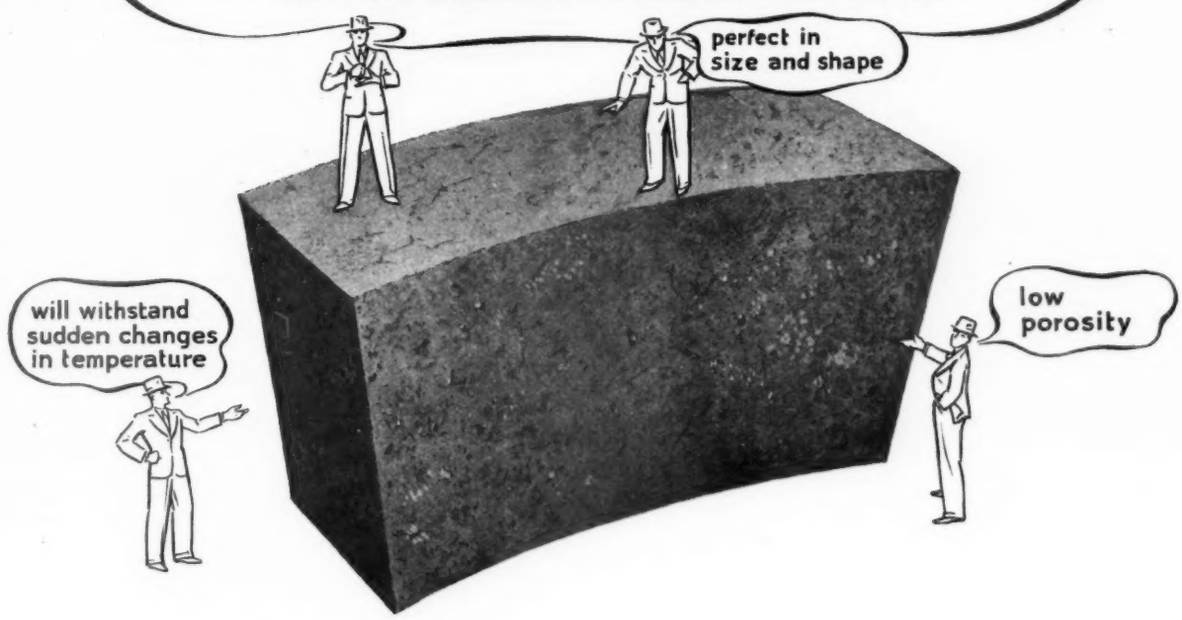

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Raw Material Markets

Pig-iron consumers now have more work on hand and stocks are being reduced at a steady rate. The full output is easily absorbed, and makers will shortly have to consider relighting additional furnaces.

Pig-Iron

MIDDLESBROUGH.—Cleveland foundry iron producers, generally, have not yet increased their outputs, but stocks have been reduced to a normal level and makers will be compelled to expand their make if the present improved demand continues. Many users are still under contract; consumers who are not committed are buying in small tonnages to meet their immediate requirements.

The hematite market is more active than it has been for many months past, and consumers are gradually reducing their delivery arrears. Also, producers' own plants are consuming a heavier tonnage. The need for any expansion in the make is not likely to occur for a considerable time, as existing contracts should be adequate to keep users supplied.

LANCASHIRE.—Consumers are calling for increased supplies under contracts, but certain users are still badly situated for work. Any new business is only of a hand-to-mouth nature, and no long-term contracts will be made before future prices are announced. For delivery up to the end of the year, offers of Staffordshire and Derbyshire brands of No. 3 foundry iron are on the basis of 114s. per ton, with Northamptonshire No. 3 at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of user. There is little change in hematite, but deliveries are moving rather more freely.

MIDLANDS.—Consumers of pig-iron in this area continue to purchase supplies for their immediate requirements only. When prices for delivery in 1939 have been fixed, it is expected that a good number of orders will be released; users are fully anticipating lower quotations, but whatever decision is made by the producers, many consumers will no doubt be compelled to enter the market, as their stocks have become low and contract commitments have in many instances expired. On the other hand, there is a good number of consumers who are still behind schedule with their contract deliveries. The turnover in low-phosphorus iron is still on a good scale, but most transactions involve only short periods, as prices are not controlled and quotations are a matter for negotiation. Current prices range from £5 10s. to £6 10s., delivered this area, the latter figure being the quotation for Scottish material. The price of low-phosphorus iron has been reduced during the past few months and any change in high-phosphorus iron may not be reflected in low-phosphorus quotations. Although consumers of hematite are rather better employed than they have been for a considerable time past, they are still well behind in taking up their contract deliveries and not much new business can be expected in this section for some months.

SCOTLAND.—Activity among pig-iron consumers in this area is better than has been the case for a long time past, but until next year's prices are announced consumers will continue to buy only their urgent requirements and deliveries will not extend beyond December 31. A shipment of 1,000 tons of Indian foundry iron which arrived in the Clyde recently was the first from this source for a considerable time. No. 1 foundry iron is quoted at 120s. 6d. and No. 3 foundry 118s., f.o.t. furnaces. There has been a slight improvement in the working time at local steelworks, but a further expansion is still needed before really satisfactory conditions prevail. Deliveries of hematite and basic are being taken up fairly well, but little new business is being placed, as most works are well covered.

Coke

A firm tone continues to rule in the foundry-coke market. Consumers are still calling for heavy deliveries and some ovens are not finding it easy to meet all orders promptly. For delivery to Birmingham and Black Country stations, best Durham coke is quoted at 50s. 6d., with Welsh coke at a minimum of that figure.

Steel

Some irregularity has developed in the steel market, but most branches of the industry are moderately busy. There is, however, a good deal of unemployed plant, but there seems to be a general expectation that the volume of business will expand in the New Year. Most consumers persist in their attitude of buying limited quantities for near delivery, and as the end of the year approaches interest in the prices which will rule after December 31 is growing. Business in the semi-finished steel branch of the industry is increasing as the stocks in consumers' hands decline. The production of this class of steel appears to be growing and larger quantities of British material are passing into consumption. The home demand in the finished-steel section is maintained at recent levels, but the producers are able to give early delivery, and would welcome a more regular flow of orders. The export side of the market is rather more active than for some time, but most overseas buyers continue to pursue a cautious policy.

Scrap

A welcome feature of the scrap market this week has been the better call for supplies of steel scrap, although this section remains far from satisfactory. Stocks, of course, have accumulated very considerably of late, and it will be a long time before there is any appreciable buying movement. Iron scrap, on the other hand, is moving away quite well, although many consumers are now well covered for their future needs.

Metals

Copper.—The demand for this metal has fallen to a low level, and the tone of the market has become subdued. Consumption in this country is maintained, but consumers are showing little interest in new business. Prices have declined, and it is now suggested that producers will shortly consider a reimposition of restriction.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £44 13s. 9d. to £44 15s.; Friday, £44 7s. 6d. to £44 8s. 9d.; Monday, £44 3s. 9d. to £44 5s.; Tuesday, £43 16s. 3d. to £43 17s. 6d.; Wednesday, £44 18s. 9d. to £45.

Three Months.—Thursday, £44 17s. 6d. to £45; Friday, £44 11s. 3d. to £44 12s. 6d.; Monday, £44 7s. 6d. to £44 8s. 9d.; Tuesday, £44 to £44 1s. 3d.; Wednesday, £45 2s. 6d. to £45 3s. 9d.

Tin.—This market, also, has become quieter and receives little support from consumers. At a meeting in Paris on Tuesday the International Tin Committee decided to make no change in the tin quota for the first three months of next year. The free export quota will therefore remain at 35 per cent. of standard tonnages, and the buffer stock quota at 10 per cent.

Official quotations were as follow:—

Cash.—Thursday, £214 5s. to £214 10s.; Friday, £214 to £214 10s.; Monday, £213 15s. to £214; Tuesday, £212 to £212 5s.; Wednesday, £215 15s. to £216.

Three Months.—Thursday, £215 5s. to £215 10s.; Friday, £215 to £215 5s.; Monday, £214 10s. to £214 15s.; Tuesday, £213 to £213 5s.; Wednesday, £216 10s. to £216 15s.

Spelter.—A dull tone has prevailed in this market, and consumers have been content to satisfy only their immediate requirements. On the whole, industrial buying has fallen to a low ebb. A sharp fall occurred in the United States zinc quotation on Monday, when the price was reduced 30 points to 4.75 cents per lb., East St. Louis.

Daily market prices :—

Ordinary.—Thursday, £14 5s.; Friday, £14 3s. 9d.; Monday, £14 1s. 3d.; Tuesday, £13 17s. 6d.; Wednesday, £14 2s. 6d.

Lead.—This market has been quiet during the past week and the outlook remains rather obscure. Building plans passed in October showed an increase of 18.8 per cent., as compared with the previous month, but there was a fall of 2.8 per cent. as compared with the corresponding month of last year.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 18s. 9d.; Friday, £16 2s. 6d.; Monday, £15 17s. 6d.; Tuesday, £15 16s. 3d.; Wednesday, £16 6s. 3d.

Scrap.—Business in this section continues to be rather difficult, and only small tonnages are changing hands.

Approximate selling prices for old metal:—New aluminium cuttings, £70; rolled, £53; cast, £30; foil, £80. Copper, £38 10s. to £44; braziery, £34. Brass (clean), £20 to £22. Zinc, £11. Lead, £15. Gunmetal, £39 to £40.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

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